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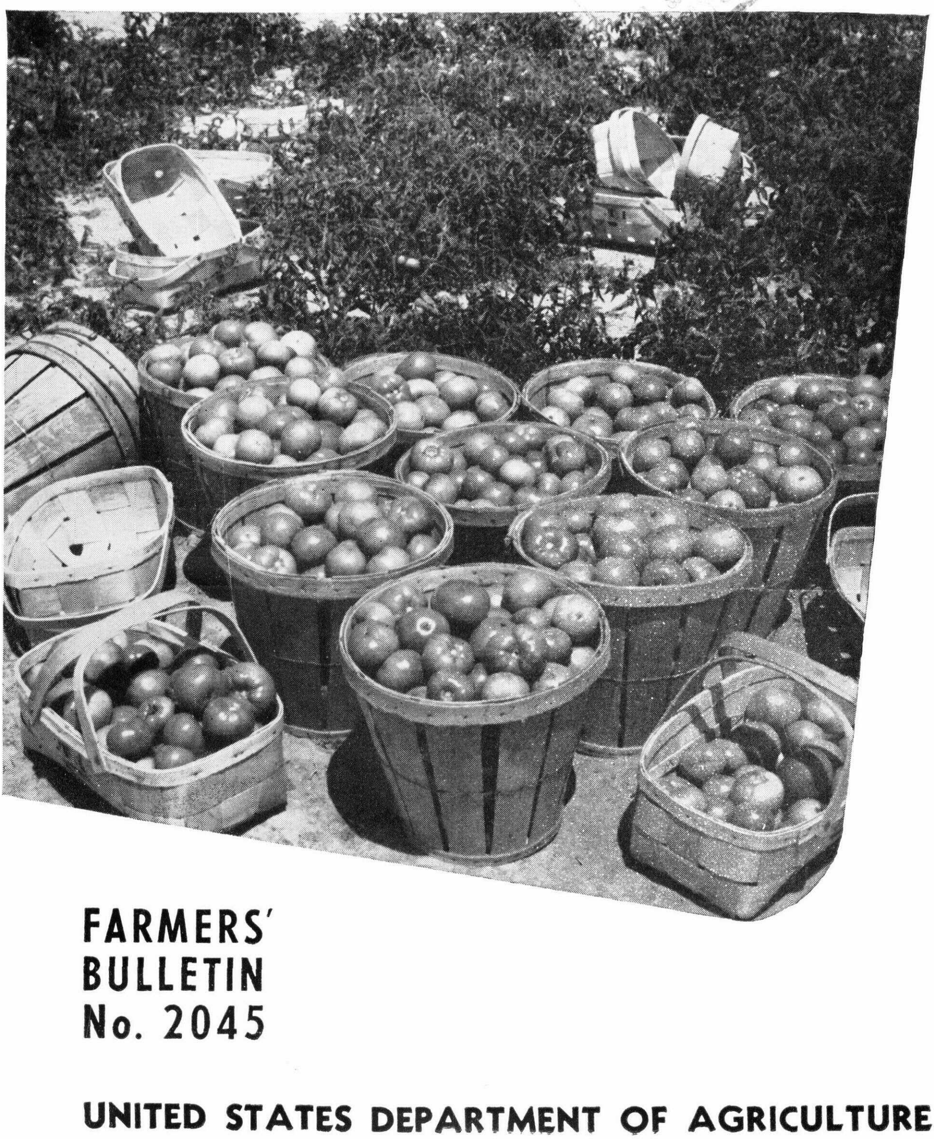
COMMERCIAL PRODUCTION OF TOMATOES



FARMERS' BULLETIN
No. 2045

UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

This bulletin supersedes Farmers' Bulletin 1338, Tomatoes as a Truck Crop, and Farmers' Bulletin 1901, Production of Tomatoes for Canning and Manufacturing.

Washington, D.C. **Revised February 1963**

COMMERCIAL PRODUCTION OF TOMATOES

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A garden curiosity when the United States was a pioneer country, the tomato has now become one of the most popular vegetable crops. It ranks next to potatoes in total value. Annually, 170,000 to 200,000 acres are now grown for the commercial production of 32 to 33 million bushels of fresh-market tomatoes with a market value of approximately 135 million dollars in 1960. The tomato crop for processing varies from about 3½ to 4 million tons a year, with a market value of about 100 million dollars, and requires about 280,000 acres of fertile soil for its production.

TOMATO-PRODUCTION AREAS OF THE UNITED STATES

Processed tomato products are found at all times in practically every grocery store in the United States. As a result of the increased demand and the rapid development of the industry in recent years, fresh tomatoes are also available in many town and city markets every month. The commercial-producing areas, shown in table 1, together with improved methods of handling and distribution make this possible.

Principal Fresh-Market Areas

Most of the tomatoes for winter and spring markets are grown in Florida, Texas, California, Georgia, South Carolina, Alabama, Louisiana, and Mississippi. Fresh tomatoes from these States are supplemented in early winter by shipments from Mexico and from Cuba and other Caribbean countries. The large vegetable greenhouses of the Northern States and Eastern States also produce considerable quantities of high-quality salad tomatoes, but greenhouse tomato production is now less than it was about 1925. In the face of competition from quantities of field-grown tomatoes that can now be shipped safely for long distances, the greenhouse operators have often found other crops—especially flower crops—more profitable.

Production Centers of the Tomato-Processing Industry

The early-summer and late-summer tomato crops include about two-thirds of the total commercial tomato acreage in the United States and furnish the bulk of the processed tomatoes. The States leading in the production of processed tomatoes, in descending order of production in the years 1949–58, are California, Indiana, New Jersey, Pennsylvania, Ohio, Maryland, Texas, New York, Virginia, Illinois, Michigan, Florida, Utah, Delaware, Arkansas, Colorado, and Missouri. The geographical distribution of the tomato-processing industry is shown in figure 1.

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[1] Retired.

TABLE 1.—*Dates for planting seedlings and for harvesting of fresh-market tomatoes in principal production areas of the United States*[1]

Seasonal grouping by States	Planting period	Harvesting period	Districts and counties or parishes
Winter			
Florida	Oct. 15–Jan. 31	Jan. 1–Apr. 15	Lower east coast: Dade, Broward. Immokalee: Collier, Hendry. Manatee-Ruskin: Manatee, southern Hillsborough.
Early spring			
Florida	Jan. 1–Mar. 15	Apr. 1–June 15	Plant City-Wauchula: Hardee, northern Hillsborough, Sumter, Marion, Levy, Orange. Fort Pierce: St. Lucie, Indian River, Okeechobee, Glades, Martin, Brevard, Highlands. Manatee: Manatee, Hillsborough. Lower east coast: Dade, Broward, and east Palm Beach. Immokalee: Collier, Hendry.
Texas	December–January	Apr. 1–June 15	Lower valley: Cameron, Hidalgo, Willacy, Starr.
California	August–February	Dec. 1–June 30	Desert valleys: Imperial (Imperial Valley), Riverside (Coachella Valley).
Late spring			
Texas	Feb. 1–Mar. 31	May 10–July 15	Falfurrias: Brooks, Riviera, Jim Wells. Yoakum: Lavaca, De Witt. East-central: Robertson, Falls, Milam, Leon. Jacksonville: Cherokee, Smith, Henderson, Shelby, Van Zandt, Anderson, Rusk, Panola, San Augustine, Nacogdoches. Avery: Red River, Bowie, Lamar.
Louisiana	Mar. 15–Apr. 15	May 20–July 10	North: De Soto, Jackson, Union, Winn, Lincoln Parishes. South: West Feliciana Parish.
Mississippi	Mar. 25–Apr. 15	May 25–July 10	Crystal Springs-Hazlehurst: Copiah, Hinds.
South Carolina	Mar. 15–Apr. 25	May 25–July 15	Coastal: Beaufort, Charleston. Central: Orangeburg, Bamberg. Northeast: Marlboro, Dillon.

Georgia	Mar. 15–Apr. 10	May 20–July 15	South: Mitchell, Cook, Lowndes, Colquitt. Southeast: Evans, Tattnall.
Alabama	Mar. 15–Apr. 15	June 1–Aug. 31	South: Mobile, Houston. Central: Chilton, Elmore. North: Cullman, Blount, St. Clair, Jefferson.
Early summer			
California	February–April	June 1–Aug. 31	San Joaquin Valley: Merced, Tulare, Fresno, Madera. South coast: San Diego, Los Angeles, Orange.
Arkansas	Apr. 5–May 10	June 1–Sept. 30	Southeast: Bradley, Drew, Cleveland, Ashley, Lincoln. Northwest: Washington, Madison, Benton. West-central: Crawford, Johnson, Sebastian, Franklin. Southwest: Hempstead, Sevier, Howard.
Tennessee	Apr. 20–May 10	June 20–Aug. 15	West: Gibson, Crockett.
North Carolina	Mar. 25–Apr. 30	June 10–July 31	Southeast: Carteret. South: Scotland, Robeson.
Virginia	Apr. 15–May 10	June 25–Sept. 10	Eastern Shore: Northampton, Accomac. Northern Neck: Westmoreland, Northumberland, Richmond, Middlesex, Essex, Lancaster.
Kentucky	Apr. 10–July 15	June 15–Sept. 30	West: Calloway, McCracken. North: Jefferson, Boone, Kenton, Trimble.
Illinois	May 1–10	July 5–Aug. 15	South: Union, Alexander, Pulaski.
Missouri	Apr. 20–May 30	June 25–Aug. 15	Southwest: Newton, Lawrence, Barry, McDonald, Jasper, Christian, Taney, Stone, Greene. East: Jefferson, St. Louis.
Ohio	May 1–15	July 1–Aug. 15	Southeast: Washington, Meigs, Scioto, Gallia, Lawrence.
Maryland	Apr. 15–June 10	June 25–Sept. 30	Eastern Shore: Somerset, Worcester, Wicomico, Dorchester. Central: Baltimore.
Delaware	May	July 1–Sept. 30	Sussex, Kent, New Castle.
Late summer			
New Jersey	Apr. 25–June 15	July 1–Oct. 31	South: Gloucester, Salem, Cumberland, Atlantic. Central: Monmouth, Burlington, Mercer. North: Bergen, Morris.
Washington	May 1–June 15	do	South-central: Yakima. West: Pierce, King. East: Spokane.

[1] Data furnished by the Economic Research Service.

TABLE 1.—*Dates for planting seedlings and for harvesting of fresh-market tomatoes in principal production areas of the United States*—Continued

Seasonal grouping by States	Planting period	Harvesting period	Districts and counties or parishes
Late summer—Con.			
Pennsylvania	May 10–June 15	July 1–Oct. 31	East: Lackawanna, Luzerne, Wyoming, Schuylkill, Columbia. Southeast: Bucks, Lancaster, Philadelphia. Northwest: Erie. West: Allegheny.
Ohio	May 10–June 10	July 1–Oct. 25	North: Lucas, Ottawa, Lorain, Erie, Cuyahoga, Fulton, Lake, Ashtabula. South: Hamilton, Montgomery, Lawrence, Scioto.
Indiana	May 1–June 15	July 1–Oct. 31	Central: Johnson, Grant, Tipton, Madison, Hamilton. Northeast: De Kalb.
Illinois	May 10–20	July 15–Oct. 31	North: Cook, Du Page, Lake, Will, Kankakee, Whiteside. Southwest: St. Clair.
Iowa	May 10–June 5	Aug. 1–Oct. 31	Central: Marshall. East: Muscatine, Linn.
New York	May 1–July 31	July 10–Oct. 15	East: Ulster, Rockland, Albany, Columbia, Orange, Dutchess. West: Erie, Orleans, Niagara, Monroe, Genesee. Central: Onondaga, Oneida. Long Island: Nassau, Suffolk.
Michigan	May 1–June 15	July 5–Oct. 31	Southwest: Berrien, Kent. Southeast: Wayne, Monroe, Macomb, Oakland. East-central: Bay (Bay City).
Colorado	May 15–June 30	Aug. 15–Oct. 10	North: Adams, Jefferson, Weld. South: Pueblo, Crowley, Otero. West: Delta, Mesa.
Utah	May 15–June 15	Aug. 15–Sept. 30	North: Box Elder.
Oregon	Apr. 15–June 15	July 10–Oct. 31	Northeast: Umatilla. Southwest: Jackson, Douglas. Northwest: Multnomah, Clackamas.
Alabama	June 1–July 31	Sept. 1–Nov. 10	North: Blount, St. Clair, Cullman.

Early fall			
California	May–July	Aug. 15–Dec. 31	South coast: San Diego, Orange, Ventura, Los Angeles. San Joaquin Valley: San Joaquin, Stanislaus, Kern, Tulare. Central coast: Santa Barbara, Santa Cruz, San Luis Obispo, Monterey, Alameda, Santa Clara. Sacramento River: Sacramento, Solano, Yolo, Contra Costa.
Late fall			
Texas	Aug. 1–Sept. 15	Oct. 25–Dec. 31	Laredo: Webb. Lower valley: Cameron, Hidalgo, Willacy, Starr. Winter Garden: Zavala, Dimmit, Uvalde, Medina, Frio. Eagle Pass: Maverick.
Florida	Sept. 1–Oct. 30	Nov. 1–Jan. 15	Fort Pierce: St. Lucie, Indian River, Okeechobee, Glades, Martin, Brevard. Manatee-Ruskin: Manatee, Hillsborough. Lower east coast: Broward, Dade, Palm Beach. Immokalee: Collier, Hendry.

The remarkable development of tomato processing in California is indicated by the production of about 2 million tons, or about half of the tonnage of the United States (1949–58).

CHOOSING VARIETIES

Varieties should be chosen that are well adapted to the conditions under which the crop is to be grown and that are acceptable to the market for which they are intended. To select the best variety for any given purpose, season, or locality, the past performance of the variety when grown in the region, the climatic characteristics of the area in which the crop will be grown, and the qualities of the tomato desired should be considered. No one variety has been developed that has adaptability wide enough to produce the best yields of high-quality tomatoes under all the conditions in which tomatoes are grown. Therefore, when a grower plans to grow tomatoes in a district that is new to him, it is advisable to select a variety that has already produced satisfactory crops in that district. New varieties should be tested in small and then in larger plantings to prove their satisfactory or superior performance in the district before the older varieties are discarded.

In choosing a variety for early local market the first consideration should be earliness, since the earliest fruit usually brings the highest market price. Earliana is and has been the standard first-early variety for many years. It is not superior in either fruit shape or quality and it has no resistance to the most common tomato diseases, yet because it has generally produced one or more ripe fruits per plant several days earlier than most other varieties, Earliana is still grown widely. In areas where earliness is of secondary or minor importance a medium-early or main-crop variety producing larger yields of higher quality fruit is likely to give the most satisfactory results.

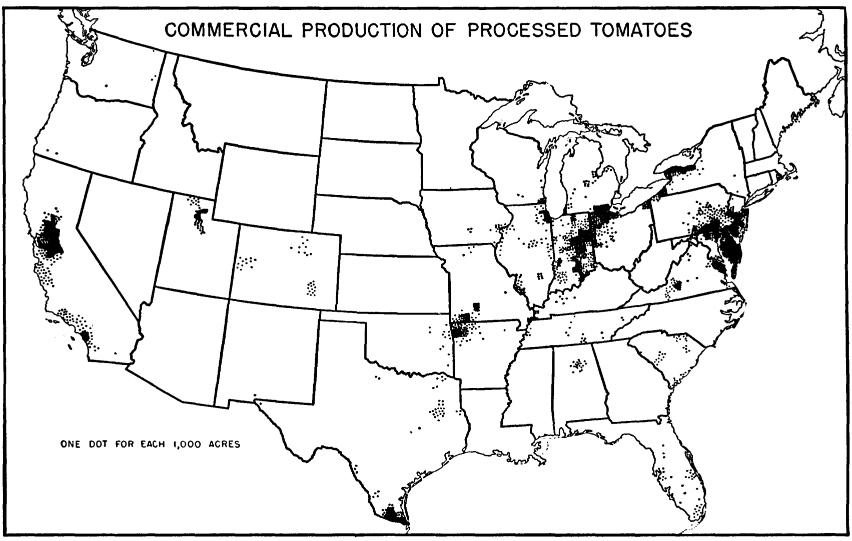

Figure 1.—**Distribution of the tomato acreage for the processing industry.**

When selecting a variety for processing the following qualities are of primary importance: High yields and fruit with uniform bright-red color throughout outer and inner fleshy walls, smooth surface, small seed cells, and firm flesh. The plant should be a strong vigorous grower that develops an extensive, deep, root system that is capable of supporting a heavy load of fruit and that produces enough heavy foliage to manufacture plenty of nourishment for the developing fruit as well as to protect the fruit from sunscald. Moreover, the variety should be adapted to the local climate and soil and its resistance to prevalent diseases should be known.

First-Early Varieties

The first-early varietal group is grown almost exclusively for early marketing and for home consumption. It is typified by the variety Earliana and the newer early varieties, the majority of which were derived from Earliana. These varieties all have the common characteristic of producing flowers early and of setting fruit during the relatively cool and moist weather of spring or during the summer in the cooler parts of the country. Their fruit is generally inferior in culinary quality to those of later varietal groups. They usually ripen the first fruits in 55 to 65 days after transplanting and tend to bear over a shorter time than do later sorts.

Earliana is a small plant with small medium-green leaves, a few sprawling branches, and with the fruit exposed. The fruits are deep oblate, medium-sized, and scarlet.

One or more of the Earliana group of varieties will be found growing in the market areas of the United States from Maine to California.

The small "bush" early varieties typified by Bounty have become popular in many early tomato-producing regions. The varieties Early Chatham, Fireball, Early Wonder, Cavalier, and Westernred are among the varieties now used. A group of early hybrids are also becoming more extensively used.

All these early varieties usually produce an abundant early crop that ripens and is finished in a relatively short time.

Second-Early Varieties

The second-early varietal group, of which Bonny Best is perhaps most typical, produces ripe fruit within 63 to 73 days after setting plants in the field. These varieties are characterized by medium plant and fruit size and somewhat more foilage than the first-early varieties. However, there are no sharply defined differences between varietal groups. The variations occurring within one varietal class tend to overlap the adjoining classes. Some of the second-early varieties are used regularly in some districts for processing as well as for fresh market. The fruit size, shape, smoothness, and color of second-early varieties are usually superior to first-early varieties, and the yields are ordinarily better. These varieties set fruit as freely in cool, moist weather as do those of the first-early group.

In New York and other Northeastern States and Canada, where the growing season is comparatively short, John Baer has been the leading canning variety for many years. This variety is practically indistinguishable from Bonny Best, from which it was selected.

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Strains of John Baer have been subsequently selected that produce heavier yields of larger and more uniformly shaped fruit. Pritchard and Stokesdale are also grown in this region for fresh market and for processing. Valiant is sold largely as a fresh market variety.

Bonny Best has a medium-sized plant, medium-green leaves, and semierect and spreading branches that shade the fruits slightly. The ripe fruits are medium size, deep oblate in shape, and medium bright scarlet in color. Radial cracks in fruits are common; circular cracks rare.

Pritchard is a medium-sized plant with large medium-green leaves and rather short, self-topping, semierect, and compact branches that shade the fruits well. Ripe fruits are nearly globular, medium in size, and bright scarlet in color. Pritchard is resistant to nailhead rust and somewhat resistant to fusarium wilt.

Stokesdale is a medium-sized plant with medium-green leaves, decumbent branches with erect tips, and fruit slightly shaded by leaves. The ripe fruits are globular to deep oblate and the color medium bright scarlet.

Valiant is a medium-small plant with rather small medium-green leaves, sprawling branches with tips somewhat erect, and fruit usually exposed. Ripe fruits are globular to deep oblate and medium bright scarlet in color. Valiant has been gaining in popularity for home and market use because its heavy yield is over a longer bearing period than Earliana. It is only 5 to 7 days later in starting to ripen, and the fruits are smoother, rounder, fleshier, and better colored.

Queens, a variety developed from a cross of Valiant and Rutgers, was introduced in 1950. The foliage is intermediate between the light foliage of Valiant and the heavy Rutgers foliage. Queens ripens its scarlet fruit about a week later than Valiant and 7 to 10 days earlier than Rutgers.

Other second early varieties used are Grothen Globe, Urbana, Gem, Glamour, and a number of available hybrids.

Main-Crop Varieties

Main-crop tomato varieties usually require from 70 to 80 days from transplanting medium-sized plants that have not yet reached the flowering stage to harvest. Under warm and favorable weather conditions fruit may ripen several days sooner. If the prevailing weather is unseasonably cool, first harvest may be delayed as much as 10 days. The varieties of this group account for the greater part of the tomato crop in the United States and include most varieties grown for processing. The Marglobe tomato is a good example and standard of this varietal group. Since its introduction in 1925, Marglobe has been a leading variety, particularly in the East and South, as an all-purpose tomato for home and market garden and for canning and shipping. It is resistant to nailhead rust and possesses moderate resistance to fusarium wilt, which has made it especially valuable in Florida and Mexico and other far-southern shipping areas. Marglobe still is an important canning variety, particularly in some of the Eastern States. The Rutgers tomato, developed from a Marglobe cross, became the leading processing variety in the Eastern States and is also used widely as a shipping tomato in the Southern States. It ripens a few

days later than Marglobe, and yields a larger proportion of the large flattened fruits that tend to make a larger tonnage per acre. Rutgers is liked especially by processors because the red interior fruit color is usually very good when the fruit is uniformly colored on the outside. The varieties Homestead and Campbell 146 which possess resistance to fusarium wilt have replaced some of the Rutgers acreage.

Indiana Baltimore has been largely replaced in the processing areas of Indiana and adjacent States by Urbana, Improved Garden State, Kokomo, Homestead 24, and Roma.

Since 1940 Pearson has become the leading tomato variety for processing in California and is also grown for market. It has grown in popularity because it sets fruit over a wide range of temperature. The ripe fruits hold up well on the plant so that the intervals between pickings may be longer. Consequently there is a heavier harvest at each picking, thus reducing overhead costs. It is well adapted to the cool coastal valleys as well as to the warm interior valleys, where there is often a daily fluctuation in temperature of 40° F. or more. New varieties of Pearson type have recently been developed, such as Pearson VF6 and Pearson VF11, that have high resistance to both verticillium and fusarium wilts. CPS–2, also resistant to verticillium and fusarium wilts, is rapidly becoming an important processing variety in California and Utah.

The red Italian-type pear varieties are becoming more generally used as processing tomatoes. San Marzano and Redtop have been used widely but are susceptible to fusarium wilt. Roma, a wilt-resistant variety introduced in 1955 is used extensively now. Redtop VR9 has been developed for resistance to verticillium wilt but is susceptible to fusarium wilt. Breeders are now developing red paste-type varieties that have high resistance to both of these tomato wilt diseases.

Marglobe, Rutgers, Indiana Baltimore, Early Baltimore, and Improved Garden State are all mildly resistant to the fusarium wilt fungus that infests many tomato fields, particularly in the more southern tomato-growing areas. All these varieties will produce a good crop if the field is only lightly infested with wilt or if the prevailing temperature is too cool for rapid growth of the fungus. However, all are severely damaged when conditions are highly favorable for growth and spread of the wilt fungus.

Pan America was the first commercial variety possessing high resistance to fusarium wilt. Since its introduction in 1940, varieties such as Homestead, Jefferson, Manalucie, Wiltmaster, Kokomo, and Campbell 146 have been developed with the Pan America type of high fusarium wilt resistance. Loran Blood and VR Moscow varieties developed for use in Utah, have high resistance to verticillium wilt.

Marglobe is a medium-large plant, semierect, with medium dense foliage that shades the fruit well. The fruits are nearly globular and bright scarlet when fully ripe. The season is 70 to 80 days from transplanting medium-sized plants that have not reached flowering stage to first harvest. The peak harvest arrives at 100 to 110 days.

Rutgers usually is a slightly larger and more erect plant with foliage that is usually a little denser than Marglobe. Ripe fruits are less globular but average a little larger and the color is similar to Marglobe. The season lasts a few days longer than that for Marglobe.

Homestead is virtually immune from fusarium wilt. The plant is large, vigorous, semideterminate, somewhat open but with adequate foliage cover of the fruits. Fruits are medium large, slightly flattened globe, bright scarlet, with light green shoulders before ripe. Grown extensively in the South for shipment. Maturity about 82 days.

Pearson is medium size, compact, semierect, with dark-green medium-large leaves and very numerous, semierect short branches. Growth habit is bushy and the dense foliage shades the fruit well. Older leaves have a tendency to roll. Fruit is a flattened globe, medium size, and bright scarlet red when fully ripe. The season is 73 to 83 days from transplanting to harvest.

Roma is an Italian type possessing high resistance to fusarium wilt. Plants are self-topping, medium-sized, fairly upright, with good foliage cover of the fruits. Fruits are small-medium (medium-size for the Italian type), definitely elongated, and tend to be a little greater in diameter at the blossom end than at the stem end; deep scarlet in color, very firm and meaty; very resistant to cracking and ground rots, will remain sound on the plants many days after red ripe; excellent for paste and intensifying color of juice and catsup. Maturity about 75 days.

METHODS OF OBTAINING GOOD PLANTS

Vigorous healthy plants are essential for the successful production of tomatoes. The choice of method of obtaining vigorous plants depends largely on the proposed use of the crop, the climate, and the customs of the locality.

Profits from the growing of market tomatoes depend largely on the marketing of much of the crop while the supply of tomatoes is limited and the demand is strong. Therefore, the grower should either have facilities for growing early plants or a reliable source from which he can buy good plants for the successful production of tomatoes for early market.

Various forms of structures for growing plants, including greenhouses, sash houses, hotbeds, and coldframes, and open beds are used for starting early plants. In determining the kind of equipment to provide for starting early plants the grower should consider the date when the plants will be set in the field, the local temperature range, and other climatic factors, as well as the cost of providing and operating various plant-growing equipment.

Coldframes are similar to hotbeds, but have no provisions for heating. Usually they are cheaply constructed frames with muslin covers that can be rolled up during mild sunny days. The cover affords protection against light frosts, sheds rain, and holds some heat within the frame during chilly weather. Glass sash, however, make the most satisfactory covers.

In northern latitudes greenhouses are generally used for the production of early plants. A greenhouse enables the grower to produce plants of more advanced development in less time than by other methods of growing, because of better temperature, moisture, and light control. However, the cost of a large greenhouse is prohibitive

for growing tomato seedlings only. If it can be used profitably for most of the year for other purposes and is available for the few weeks at tomato plant-growing time, costs of growing tomato plants may be kept at a reasonable level. Actually, most of the tomato seedlings are grown in open fields in the South and shipped northward, or are started in coldframes and in hotbeds. As hotbeds are so important in producing early plants for the tomato crop their construction and management are described in some detail.

Hotbed Construction

Hotbeds and coldframes should always be located on well-drained land that is free from danger of flooding. A southern slope protected on the north and west by buildings, trees, or hedges is a desirable site. The frames are covered with cloth in the warmer districts and with glass sash in the cooler districts. Glass sash give much better protection from cold and allows much more sunlight to reach the bed than does a cloth cover. Glass sash also shed hard rain, much of which may go through cloth and tend to chill the beds and make them too wet. The initial cost of glass sash is much higher than a cloth cover, but the sash can be used for many years if handled with care. A cloth cover can rarely be used more than 2 or 3 seasons.

In locations too far north for cloth to be suitable, glass gives better results than the commonly available "glass substitutes," because it transmits light better than the other materials. The sturdiness of glass sash makes it much easier to cover and uncover the beds when additional protection of straw or mats is needed. Furthermore, in regions where much heating is required much of the higher cost of glass sash will be offset through savings in heating costs.

The frames of hotbeds are usually made 5 feet 8 inches in width to fit the standard hotbed sash, which is 6 by 3 feet. The bed length is usually a multiple of 3 feet. Temporary frames are made of lumber and permanent structures are made of brick, hollow tile, concrete, cinder block, or concrete block. Permanent structures have a relatively high first cost, but the building of temporary frames every year is also costly in labor and in depreciation of material.

The frames for beds covered by a single sash length are built with one side, usually called the back, 8 to 10 inches higher than the other to give an effective slope to the sash. The low side should extend at least 8 inches above the final soil surface in the bed. The entire frame and cover assembly should be well fitted and tight to keep the heat in.

The lower sides of the frames for double-width beds for glass sash are at least 8 inches above the soil surface and 11 feet 4 inches apart. Down the middle a ridge is mounted on a row of posts 8 to 10 inches higher than the sides, or the height of the back side for single sash. For cloth covers the ridge may be only a pole or other narrow member, but for sash covers it should be wide and strong enough to carry the upper ends of the two rows of sash—2 by 4 or 2 by 6 lumber laid with the broad side flat.

All wood in permanent structures should be of cypress, redwood, or other rot-resistant wood.

On farms where plenty of fresh horse or mule manure is available, this is usually the cheapest material for heating a hotbed. On the other hand, the labor of handling and preparing the manure for the bed and the difficulty of not being able to control the heat accurately are disadvantages.

Only manure that has not gone through a period of heating should be used. To prepare it for the hotbed it should be thoroughly mixed, moistened throughout if it is not already uniformly moist, piled, and turned and mixed two or three times. This should be done just before the bed is prepared so that the manure will start to heat soon after it is put in the bed.

In the areas of milder weather the manure can be packed down on the soil surface in a flat pile about 3 feet wider and longer than the covered movable frame (fig. 2). About 4 inches of a friable loam soil should then be spread and leveled over the packed manure, and the frame set up on the top of the leveled soil.

It is usually better, however, to dig a pit of suitable depth a foot wider and longer than the temporary frame and to pack the manure into this pit approximately to ground level. Soil is then put over the manure 3 to 4 inches deep, and the frame is put in place and then banked with soil around the outside.

In the warmer districts well-packed manure to a depth of only 6 to 8 inches will give enough heat. In the cooler districts a depth of 8 to 12 inches is usually necessary. After the cover is put in place several days must elapse for the fermentation of the manure to reach its peak. When the temperature of the soil has gone down to 80° F., tomato seed may be sown in the frame or young seedling plants trans-

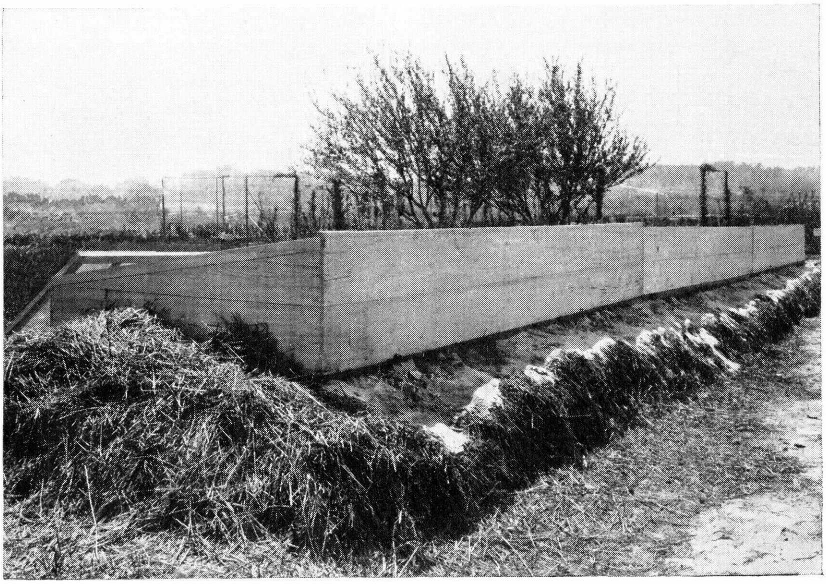

Figure 2.—**Manure-heated hotbed built entirely above the ground level.**

planted to it. It is necessary to have a good soil thermometer and to note the temperature at least once daily to know the condition of the bed.

Manure-heated beds may be as long as desired, as the source of heat is distributed throughout the length of the bed.

Manure that is contaminated with remains of diseased tomato vines and fruits should not be used for heating tomato hotbeds.

Flue-Heated Beds

If electric power is not available or too expensive for heating hotbeds and if manure is not available or considered undesirable, tomato beds may be heated by flues leading from a firebox under one end of the bed to chimneys at the opposite end. Wood is the usual fuel. Flue heating is satisfactory for beds up to 50 feet long. If the flues are longer than that, the end of the bed opposite the firebox cannot be kept warm enough unless the end near the firebox is kept too warm.

One type of installation is built as follows: 8-inch clay-tile flues are buried in the soil 2½ feet apart on centers. At the firebox end of the bed the flues are about 18 inches below the level of the soil surface in which the tomatoes are to be planted. The flues slope upward slightly, reaching only about 8 inches below the soil surface at the opposite end. Fireboxes are constructed in many ways. Some are well-built brick or stone structures with iron doors. Others are no more elaborate than an old oil drum laid on its side with one end cut out and the other end connected to the flue. Chimneys are of sheet metal, tile, or even wood. Wood construction exposed to the hot flue gases is, of course, a fire hazard.

A more common flue-heating arrangement consists of a heavy wooden hotbed with floor or bottom of cheap lumber built over a long, narrow, shallow pit. The bed is usually supported on heavy, cheap, rough-hewn wooden timbers. There is a firebox about 6 feet away from one end of the bed that discharges hot gases into an earthen passage leading to the pit under the bed. The firebox is set back to reduce the danger of setting fire to the wooden bed structure or of overheating the bed. There is a chimney at the opposite end. The fire hazard is greater in this kind of bed than in the kind heated by buried tile. The damp soil and watering of the bed, however, keep the wooden structure moist enough that it will not catch fire, provided the fire is well controlled.

The wooden bed constructed over a pit was formerly considered economical and relatively efficient. Under many conditions today, however, it is too expensive because of the relatively high costs of labor and materials for construction, of labor and fuel for heating, and of the high rate of depreciation. The fires of such beds require frequent attention and heat-waste is high. The pit method of heating is being rapidly displaced by electric power.

Electric-Heated Beds

As electric power at reasonable rates becomes available to more and more farmers, the old-fashioned manure-heated and flue-heated beds tend to become obsolete. Beds to be heated by electricity should be

very well built and thoroughly insulated in order to hold the power cost down to a reasonable figure. Even at relatively low rates for electricity a poorly built hotbed will be too costly because of the power that will be wasted in it. In some communities the electric rates are too high for economical use in heating hotbeds. Representatives of all power companies that serve rural areas are familiar with the power requirements of electric hotbeds in their own localities and can estimate probable costs at the existing rates. Rural electrification specialists at the several State agricultural experiment stations and county agricultural agents can also advise growers of probable local costs.

The costs for construction of suitable beds and for electric power may tend to discourage many prospective users of electric hotbeds. With these costs, however, must be compared the great savings in labor and the improved results obtainable with automatically controlled electric heat. When these factors are considered, electric beds are often found to be the least expensive.

For electric heating permanent structures have many advantages over temporary ones. In the cooler regions where much heating is necessary fairly elaborate provisions against heat loss are justified. These conditions usually can be supplied at a lower cost for a period of years by a well-planned, well-built structure that does not have to be rebuilt every year.

In cool areas the bottom of the bed should be excavated about a foot below the soil level. About 4 inches of coarse gravel or coarse cinders is put in the bottom to keep the heated part of the bed well away from the cold, wet soil below. This is covered with a layer of clean straw or other coarse litter that will settle down to a thickness of about 2 inches when soil is put on top of it. The coarse litter gives additional insulation from the cold bottom of the bed, to keep much heat from being lost downward. The litter is then covered with a thin layer of soil about 1 to 1½ inches deep and carefully leveled over the entire bed. The heating cable is placed on the surface of this soil layer and electrical connections are completed. Three to four inches of fertile sandy loam soil or light loam is put over the cable, the thermostat bulbs and thermometers are put in place, the sash are put on the bed, and it is ready for heating to be started. Some variations in these directions may be made, depending upon local weather conditions and materials available for preparing the hotbed. Good drainage, tight construction, tight covers, and thorough insulation must, however, always be provided.

ELECTRICAL EQUIPMENT

Detailed information on electrical wiring or electrical heating equipment can be obtained at first hand through representatives of local power companies or cooperatives. The principal features of more or less standard electric hotbed equipment and its use are, however, described briefly.

Standard lead-sheathed hotbed heating cable is recommended. It is made so that a single element, or loop, must be 60 feet long for operation on 110 to 115 volts or 120 feet long for 220 to 230 volts. The 60-foot element consumes approximately 400 watts of power, and the 120-foot element 800 watts. Under most conditions a 60-foot element is recommended for each two standard sash, or 6 by 6 feet of bed. Similarly a 120-foot element will heat the equivalent of four sash,

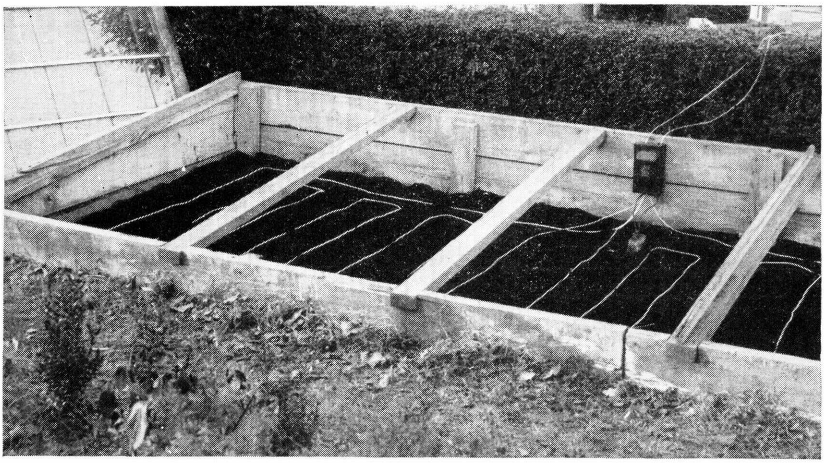

Figure 3.—An electric-heated hotbed, showing arrangement of heating cables.

or 6 by 12 feet of bed. Figure 3 shows a practical method of arranging the cable in the bed to give uniform distribution of heat. The strands of the cable should be no more than 8 or 10 inches apart in the bed.

Automatic control is furnished by effective thermostats that are available at reasonable cost. One standard hotbed thermostat, rated at 25 amperes, will handle a maximum of 6 of the heating elements described—for 12 sash at 110 volts or for 24 sash at 220 volts. In locating thermostats and laying the heating elements in large beds, it is generally better to arrange them by groups of sash than to have part of the area under any group of sash controlled by one thermostat and part by another.

Permanent locations for electric-heated beds are desirable in order to avoid the considerable cost of relocating power lines that serve the beds from year to year. For beds of permanent construction good weatherproof electrical installations and fittings will save much time and trouble over a period of years. Crude, temporary installations may be satisfactory for any one year, but they require more labor for repeated installations, they are likely to be less efficient in the use of power, and the electrical equipment will be shorter lived than in permanent ones.

The soil in the frame should be renewed or sterilized each year as soon as the frames are empty in early summer. At this time the heating cables should be carefully taken from the beds, straightened out, then rolled into large, neat coils for safe storage. The thermostats should also be stored carefully.

Some operators lay 4-mesh hardware cloth over the heating cables in the bed to guard against damage to the cable by tools used in working in the bed. The lead covering of the cable is easily cut or broken by striking it with a shovel when removing or turning the soil. If no hardware-cloth protection is installed, no tools should be used in the bed until all plants have been removed, and the lead cable carefully removed by hand. Take care to avoid kinks in the cable or sharp blows that might break the lead sheath.

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The elongated bulb of the hotbed thermostat should be buried horizontally in the bed about an inch above the heating cable. It should be placed about the middle of the area controlled by the thermostat, and a good soil thermometer should be placed next to it with the thermometer bulb at the same depth. The control knob on the thermostat should be adjusted so that current will be turned on and off at about 65° F. The thermometer should be read from time to time to insure that the thermostat has been set right, and the bulb placed so that it can maintain the desired temperature at the level chosen in the bed. Operating instructions are furnished with each instrument.

Hot-Water-Heated Beds

Heating hotbeds by hot water in iron- or steel-pipe coils is less common than it used to be. Although the method is effective, it has been largely displaced by electrical heating. Original costs of such pipe installations are relatively high for the short seasonal use made of them. If an ample source of hot-water heat is available in connection with other operations, such as heating a building, a greenhouse, or a poultry brooder house, costs for the hotbed may be substantially lower. Hot-water heating for use only in growing tomato plants is of doubtful economy under most conditions. If, however, other available methods of heating have serious drawbacks in certain situations, hot-water heat may be worth while. It is also feasible where a cheap gas supply is available. You may contact your county agent or State agricultural experiment station for additional information on heating methods for hotbeds and greenhouses.[2]

Preparation and Sterilization of Seedbed Soil

Seedbed soil should be rather light in texture but with good moisture-holding capacity, and it should contain sufficient quantities of all essential plant nutrients to produce a thrifty growth. It may be prepared by composting 3 parts of chopped-up sod with 1 part manure. This mixture should be prepared at least a year before it is to be used and should be turned several times during its processing. Great care should be exercised to avoid growing plants in soil that has been used to grow tomatoes or related crops within the preceding 3 years or upon which manure containing tomato refuse has been spread. The danger from nematodes and soil-borne diseases can be greatly reduced by heat or by chemical sterilization of the plant-bed soil, of the boxes used in starting the seed, of the greenhouse benches, and of the framework of the plant beds.

Steam may be applied by means of an inverted pan connected to a boiler with steam hose, or it may be applied to the soil through a steam rake having hollow teeth spaced 6 or 7 inches apart that discharge the steam at a depth of 6 or 7 inches below the surface of the seedbed soil. The rake is constructed of pipe and connected to a steam boiler by a steam hose. It is moved along the soil bed as the

[2] These and other Farmers' Bulletins listed in this bulletin are available free from the Office of Information, U.S. Department of Agriculture, Washington 25, D.C.

soil becomes heated to 210° F. It is best to cover the heated soil with canvas to retain the heat as long as possible.

Saturating the plant-bed soil with a solution consisting of 1 pint of commercial formaldehyde in 30 gallons of water is effective, but treatment should be given at least 2 weeks before sowing seeds and the soil should be stirred twice to hasten the liberation of the formaldehyde fumes. Chloropicrin, or tear gas, and methyl bromide are used also for disinfecting soil. These materials are sold under various trade names and should be used as directed by the manufacturers.

Good Seed Sources Essential

The cost of high-grade tomato seed is relatively small compared with the total cost of growing the crop. Therefore, tomato growers cannot afford to take the risks involved in using seed of inferior or unknown quality. There are 7,500 to more than 10,000 tomato seeds per ounce, depending on variety and conditions of growth, so 1 ounce of seed under the best cultural conditions will produce enough plants to set 2 acres as tomatoes are usually grown. As tomato seed retains its vitality for several years when stored in a relatively dry atmosphere (65 percent humidity or lower) and at a uniform cool temperature (65° F. or lower) some growers purchase their seed a year in advance, in order to grow a test crop a year before using it to grow the main crop. Commercial producers of tomato seed sometimes employ trained plant breeders to assure the proper maintenance and improvement of their seed stocks. Moreover, some of the main tomato-seed-producing States have established systems of State inspection and certification of tomato seed. Certified seed must meet high standards of trueness to variety type and freedom from seed-borne disease organisms. Most seed firms are able to supply certified seed of a few of the more important varieties. Seed firms growing selected varieties under such supervision are in a position to supply tomato growers with seed of a practically uniform seed stock that insures uniformity of the crop at harvesttime.

PLANT GROWING IN VARIOUS REGIONS

The plant-growing methods used in different localities vary with the earliness or lateness of the crop to be grown. To produce large, sturdy plants for a first-early market crop the seed should be sown 7 to 8 weeks before the first safe date for field planting. The plants, kept cool and provided with plenty of ventilation the last 2 weeks before field planting, become strong and stocky, develop an extensive root system, and are ready to flower at the time of field planting (fig. 4). In the growing of tomatoes for processing, earliness is a less important consideration except as it lengthens the harvest season, thus tending to avoid gluts at the canneries, and increases total yields.

In the Middle Atlantic States a popular method of growing early tomato plants is to sow the seed in heated sash houses or hotbeds. The plant beds are prepared for seeding at least a week in advance of sowing so that the soil will be warm when seeded. They are filled with well-fertilized composted soil to a depth of about 6 inches. The soil temperature is maintained at about 70° F. to insure quick even germination, and the seedlings usually come up in about 5 days.

Figure 4.—A sturdy pot-grown tomato plant, with well-developed root system produced by transplanting twice.

Seed is planted at the rate of an ounce for each acre of tomatoes to be grown.

The rows are usually made 6 inches apart from center to center, crosswise of the beds or benches, the edge of a board being used as a marker. When the rows are opened up about half an inch deep and 3 inches wide, the seed is scattered over the 3-inch-wide row at the rate of about 100 seeds per foot of row. An ounce of seed will plant about 40 square feet of bed space. The seeding may be quickly done with the aid of a can with a perforated top. This can is often fastened to a stick to facilitate shaking out the seeds in the far ends of the rows. The seeds are covered not more than half an inch deep by leveling the soil with a lath or straight stick. The beds are then watered with a fine hose nozzle to avoid washing out the seeds. Fre-

quent light watering of the soil surface will prevent a crust forming before the germinating seeds break through the soil. After the seedlings are up they are watered only when necessary to maintain steady growth, preferably in the mornings of clear days so that the plants and soil surface will soon dry off. This helps to avoid damping-off of the young seedlings.

To conserve heat in the beds during cold weather, mats or other covers are sometimes kept on the sash continuously until the seeds germinate. When the seedlings begin to appear the covers from the sash are removed at once to permit the entrance of all the light possible. The temperature is reduced to about 60° F. during the day so the tiny plants will grow short and stocky with the two seed leaves (cotyledons) spread out near the soil. Excess heat and lack of light at this stage will cause the plant to grow weak and spindling in a short time. After the little plants become established the temperature is maintained at about 70° during the day and 55° at night. In 4 to 5 weeks after seeding the plants should be 3 to 4 inches high, strong and sturdy, and ready for the coldframes, sometimes called "spotting beds."

Coldframe Plant-Blocking System

The method perfected in southern New Jersey for handling early plants does away with individual plant containers of any kind. However, this special method makes it possible for each plant to develop in a 4- to 5-inch block of rich compost and soil. Great care is used in preparing the coldframe compost so that it will be of the proper consistency to form a firm—but not hard—block when the tomato plants grow in it. Only well-rotted manure is used. A 2- to 3-inch layer of composted manure is packed in the evened bottom of the frame. Upon this a 2- to 3-inch layer of a sandy loam is leveled and firmed. The plants are spaced 4½ to 5 inches apart in each direction by a spotting board set with wooden pegs at proper distances. This accurate check spacing of the transplanted plants in the coldframes enables the grower to "block out" each plant in the frame by cutting through the compost between the plants in both directions. The compost should be fairly warm to avoid chilling the plant roots when they are set in the frame. The coldframes are managed so most of the plants are about 12 inches high and thoroughly acclimated to withstand weather conditions in the field 3 to 4 weeks after they are spotted in the frames. The crown cluster of buds should be ready to blossom and the branches should be developing flower buds when transplanted to the field.

In a modification of the method above that requires less seedbed space, the tomato seed is sown in wooden flats about 12 by 24 inches and 3 inches deep (fig. 5). Usually the flats are filled with composted sandy loam. Furrows ½ inch deep and about 2 inches apart are pressed into the firmed sifted soil across the flats. Fifty to 75 seeds per foot of furrow are sown and covered with soil, sand, muck, or vermiculite. A somewhat higher percent germination of the seed is usually obtained when the seed is covered with a very lightweight material, such as vermiculite, muck, or their modifications, that does not crust and is very retentive of moisture. Vermiculite or muck may be used as the sole germination medium in the seed flats. These

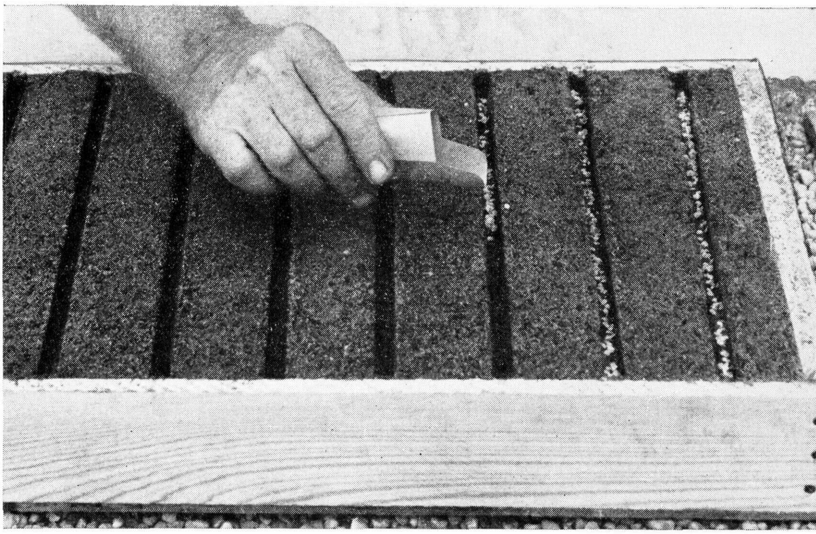

Figure 5.—**Sowing tomato seeds in a flat—a method commonly used for starting tomato plants when a greenhouse is available.**

materials can be sterilized and used repeatedly for this purpose. Sometimes it is necessary to water with a weak nutrient solution if the seedlings remain in the flats for some time after germination. In any method it is important to keep the soil around the seed moist until after the seeds have sprouted, after which the surface soil or other medium should be wet no oftener than necessary to keep the young plants growing. The young seedlings should be transplanted as soon as their stems have straightened and the seed leaves (cotyledons) have opened horizontally, which is usually 10 to 14 days after sowing the seed. Seedlings may be spotted in flats of composted soil 3 by 3 inches or 4 by 4 inches apart, depending upon the size of plants wanted for field setting. The soil between the plants is cut in both directions a week before field planting to retain a block of soil around the roots of each plant and to make removal of the plants from the flats easier. Some growers use plant bands, which make blocking unnecessary. A few growers transplant the young seedlings to pots.

Open-Field Plant Beds

Most of the plants for the commercial tomato crop are grown in open planting beds or fields in the South and shipped northward by rail express, by truck, or by plane.

Plants that will produce the southern fresh-market crop, the late northern fresh-market crop, and the greater part of the processing crop are usually started in open-field beds. In California more than half the plants that produce the large cannery crop are grown by direct seeding in coldframes. A common rate of seeding is 25 to 30 seeds per foot in rows 6 inches apart. Plants for a small percentage of these fresh-market and processing crops are started in hotbeds and coldframes or directly seeded in the cropping field.

Seed may be planted in the open as soon as danger of frost is past,

but germination is slow if the soil remains cold and wet. The date of seed sowing must be determined in each locality by the weather and the date the plants will be wanted for field planting. It is better to keep the plants growing steadily from the start than to have them too early and have them severely checked in growth. The dates for planting the seedlings and harvesting the tomatoes are shown in table 1 (p. 2) for the principal fresh-market production areas of the United States. The seed should be sown in open beds or fields 8 to 10 weeks before the average field transplanting date, with the average daily mean temperature for the season and locality taken into account.

In small open seedbeds tomato seed is usually sown in rows 12 to 15 inches apart by means of a hand drill. The plants should be spaced about an inch apart in the row. Black building paper may be used to cover the soil during the germination period to provide extra heat and reduce loss of moisture. Great care must be taken to remove the paper cover when the first seedlings begin to break through the soil.

Plants grown in open beds or fields are generally hardier and stand transplanting to the field better than those grown in greenhouses, hotbeds, or coldframes, except when the plants are transplanted with a block of soil in which they grew. Figure 6 shows good plants produced in the open without transplanting, and figure 7 shows a good plant grown by the method involving transplanting and blocking out.

The open-field method of operation is similar to but on a larger mass-production scale than the open-bed method and is the cheapest way of growing plants. This method is used by the large commercial plant growers and shippers of southern Georgia, Florida, Mississippi, Tennessee, Virginia, Illinois, and certain areas of southern Texas. It is applicable only when frost is not a hazard and normal soil temperatures are suitable.

The seed is drilled in rows 15 to 18 inches apart, at the rate of about 20 seeds per foot of row, averaging about 4 pounds of seed per acre, and the plants are not thinned. Seeding is done by means of tractor-drawn gang-seeder outfits that harrow the ground, place the fertilizer, and sow the seed for 4 or 5 rows all at one operation. The plants are cultivated by power cultivators that work 4 or 5 rows at one time. Power sprayers and dusters are used that spray up to 12 rows at a time.

Hundreds of millions of tomato plants are grown by the open-field method and shipped to the great midcountry and northern canning centers. Pulling the plants begins when they are about 6 to 10 inches high. They are bunched (fig. 8) in bundles of 50 or 100 as they are pulled and taken to a packinghouse, where the roots are packed in wet peat or sphagnum moss and wrapped in paper. The bundles are then packed in hampers or crates for shipment.

Plants also are grown by the open-field method in certain sections of California and Nevada. The seed is usually drilled with small hand seeders in rows 15 to 18 inches apart on raised beds with two rows per bed. The beds are usually spaced 30 to 36 inches from center to center and the furrows between the beds are used for irrigation.

Direct Field Seeding

Direct field seeding is not generally feasible for growing an early market crop. Its use is confined to regions of long growing season

Figure 6.—A bunch of stocky tomato plants grown in an open seedbed without transplanting.

Figure 7.—A good tomato plant grown by the spotting and blocking-out method, with one transplanting.

Figure 8.—A field of southern-grown tomato plants, showing workers pulling and bunching.

where earliness is not a factor. This method does away with transplanting, but it is wasteful of seed and requires considerable labor for thinning and weeding the plants. However, it has the distinct advantage of reducing the chances of spreading virus diseases among the plants, especially early in the season, as these diseases are readily transmitted by the handling of plants in transplanting.

Growers of summer-processing tomatoes in Ohio and Indiana are now establishing part of their acreage by direct field seeding. In California all the Coachella and the Imperial Valley tomato crops, much of the late San Joaquin Valley green-wrap crop, and an increasing percentage of the cannery crop are seeded directly in the field. Field seeding requires more accurate timing of all operations than do the other methods commonly used. The important considerations are having the soil warm and moist enough for seed germination, freedom from competing weeds, and freedom from damaging frost or prolonged chilling after emergence.

SELECTING LAND FOR GROWING TOMATOES

Tomatoes are grown on a wide range of soils. They have been successfully produced on soils ranging from mucks and heavy clays to light sands. Good drainage in any type of soil, however, is essential. The roots of tomatoes become progressively more susceptible to injury from excess water in the soil as the plants approach maturity. A soil flooded with water for a few hours, especially in very warm weather, will cause the death of most of the feeding roots and subsequent wilting and, in some instances, dying of plants.

A deep, fertile, well-drained loamy soil that is retentive of moisture is most satisfactory for heavy production of high-quality tomatoes. The humus content of the soil is very important and should be main-

tained by moderate applications of barnyard manure or by growing green-manure crops.

A "quick soil" is best for the production of an early-market crop. Such a soil becomes dry enough to be worked early in the spring and warms up quickly. Light sandy loams with a southern or southeastern slope commonly are "early" soils, especially if they are protected by woods or windbreaks on the north and west sides.

The heavier clay loams with clay subsoil are not so early as the light soils, but they are usually more retentive of moisture and of soluble fertilizers. These heavier soils are more suitable for midseason and late crops and in general produce a heavier tonnage throughout a long crop season than light sandy soils.

SOIL MANAGEMENT AND CROP DIVERSIFICATION

The best available farming practices should maintain not merely the fertility of the soil but should improve its productive capacity also.

Erosion must be prevented by plowing and planting on the contour if the land slope requires it; by keeping the soil surface protected with close-growing crops as much of the time as feasible; by working organic matter into the surface to increase water penetration and reduce runoff; and by strip cropping or terracing the steep slopes requiring such measures. Detailed publications on soil-conserving practices are available from most State agricultural experiment stations and from the Office of Information of the United States Department of Agriculture. County agricultural agents should be consulted for local recommendations.

Tomatoes fit well into a wide variety of cropping sequences on general farms, truck farms, and dairy farms. On farms producing livestock or dairy products, tomatoes are effectively grown in rotation with hay, pasture, corn, small grains, or legumes, preferably after some crop other than sod. Cutworm or wireworm injury to tomatoes following sod may be relatively heavy. Whenever it is necessary to turn under sod for a tomato crop the plowing should be done several months in advance of planting time if possible.

In regions where vegetables are grown extensively for processing, tomatoes fit into rotations or into diverse-crop sequences that include such crops as sweet corn, beans, peas, pumpkins or squash, cabbage, and one or more of the farm crops mentioned in the preceding paragraph.

Good truck farmers avoid growing any one crop too often in one field, but in general they are less inclined to stick to definite rotations than operators of livestock or general farms. Rapidly changing market prospects and the effects of pests or weather often justify quick changes in cropping plans. The crops grown for fresh market in addition to tomatoes on individual truck farms differ greatly from one part of the country to another. Some growers produce the same few crops from year to year; others produce many vegetables each year or shift from one group of crops to another at short intervals.

Since the best rotation involving tomatoes depends upon many groups of factors on different kinds of farms in various parts of the United States, it becomes a problem that should be worked out for each locality and farm. Therefore, no specific crop sequences are suggested here. It is the proper diversity of crops rather than any

specific order of rotation that is commonly most important in maintaining crop yields and in controlling soil-borne diseases and pests.

Generally, tomatoes or botanically related crops, such as potatoes, should be grown only once in 3 or 4 years on the same land. Whenever possible, at least one deep-rooted legume, such as alfalfa, should be grown every 3 or 4 years. If a nonlegume, such as rye, is used as a winter cover crop in the cooler parts of the country, the equivalent of 50 pounds per acre of nitrogen in the form of ammonium nitrate or sodium nitrate should be applied in the spring before plowing down the rye in order to hasten its decomposition and the production of humus.

PREPARING AND CARING FOR THE LAND

Good soil preparation is important in the successful culture of tomatoes. The land should be plowed about 8 inches deep either in the fall or early spring. Fall plowing is preferable, except where much erosion is likely to occur. It promotes more thorough disintegration of roots and other organic residues in the soil than spring plowing, because the alternate freezing and thawing puts the soil in better physical condition and tends to destroy more crop pests that overwinter in the soil. Fall-plowed land should be left in the rough until spring or sown to a winter cover crop that will not interfere with early-spring preparation and planting. If left unplowed until spring the land should be plowed as early as the soil is dry enough. No soil should be worked while wet. Heavy clay soils are especially subject to serious physical damage from tilling while too wet. It is not desirable to increase the depth of plowing suddenly by turning over 2 or 3 inches of previously unplowed subsoil. If the depth of plowing is gradually increased from year to year, the layer of fertile cropping soil can be deepened without affecting current crops.

Soils having an impervious (heavy clay or hardpan) layer about a foot below the surface are greatly improved for tomato production if the underlying soil is broken up without being brought to the surface. Plowing at the same depth year after year frequently develops a somewhat impervious layer called a "plow sole." Impervious layers can be corrected by an attachment to the plow that works in the bottom of the furrow and breaks the subsoil to a depth of 6 to 8 inches below the regular plow bottom.

Fertilizers and Manures

The practices governing the use of manures and commercial chemical fertilizers for tomatoes vary with the locality and the soil. Many growers prefer to apply manure to the crop preceding tomatoes rather than to the tomato crop itself. Because of the increasing scarcity and cost of barnyard manure in most localities, it is usually best to make rather light applications of 6 to 8 tons per acre. Experiments have shown most profit from these lighter applications. In many places the cost of manure has become prohibitive, so the farmers are depending more and more on green-manure crops as a means of maintaining organic matter in their soils.

When well-decayed manure is available, a light application worked into the soil before planting tomatoes is especially valuable if the organic content of the soil is low and the available plant nutrients in

the soil have become depleted. Where the organic content of the soil is already high, care should be exercised in determining if manure should be applied. If it builds up an excessive supply of nitrogen, manure has a tendency to produce a heavy vine growth at the expense of fruit setting. This in turn will cause delay in maturing and ripening of the fruit and may reduce yields considerably.

CHOICE OF FERTILIZER

The judicious use of commercial fertilizers is generally profitable. Much depends upon the previous treatment of the land, especially as to the use of manure and soil-improvement crops. In soils high in available nitrogen it is essential to balance that nitrogen with a high level of available phosphorus and potassium to prevent the undesirable effects of excessive nitrogen.

Under favorable climatic conditions well-nourished plants produce fruit of quality superior to fruit from poorly nourished plants. Therefore, the food supply of the plant should be adjusted for the production of high-quality fruit. Adequate available nitrogen improves the yield and quality by increasing the foliage produced. Ample foliage increases the food-manufacturing surface of the plant and protects the fruit from sunscald. Phosphorus promotes a large deep root system and a vigorous plant capable of high fruit production. Sufficient potash, by tending to retard foliage breakdown, reduces the number of yellow-shouldered fruits.

The tomato requires a good supply of phosphorus for promoting early yield and in maintaining productiveness. Available nitrogen, however, is the element most likely to be deficient in most soils because it leaches out of the soil so easily. Supplying the correct amount of nitrogen—just enough and not too much—is perhaps the most difficult problem of fertility for tomatoes. The available nitrogen should be relatively low during the early stages of growth, and it should not be greatly increased until after the plants have started setting fruit. From this stage on until fruiting is well advanced there should be a larger supply of available nitrogen together with adequate amounts of phosphorus and potash. Abundance of phosphorus tends to counteract the delay in maturity caused by an excessive supply of nitrogen. On most soils potash is most likely to be third in importance as a limiting fertilizer element in tomato production. The best results from potash fertilizers can be obtained only when sufficient quantities of phosphorus and nitrogen are also present in the soil. Some soils, particularly in the West, show no response to potash applications. In California the usual recommendation is for 60 to 80 pounds of nitrogen per acre and in some localities it is well to apply 50 to 100 pounds of phosphoric acid.

Under the most prevalent soil conditions a fertilizer well adapted for tomatoes should range, in analysis, from about 4–12–4 (the figures refer to the percentages of nitrogen, phosphoric acid, and potash, respectively) or 5–10–5 to 5–10–10.

The secondary elements calcium, magnesium, and sulfur are essential for tomato production, but they are usually added in sufficient amount when superphosphate is used as a constituent of mixed fertilizer and when dolomitic limestone is added periodically to correct

soil acidity. The secondary elements are important nutrients from the standpoint of providing adequate foliage and mineral content of the fruit.

Boron often improves the production of tomatoes grown in regions of high rainfall. The need for boron is diminished or eliminated when barnyard manure is used. When needed, a suitable rate of application is usually about 10 pounds of commercial borax per acre. Boron as well as certain other minor elements—zinc, copper, and manganese—are sometimes present in commercial mixed fertilizers used for tomato culture. However, there are enough of these elements in most soils to supply the needs of crop plants; and in some localities there may be actual danger of crop damage, owing to excess of one or more of the minor elements.

METHODS OF APPLYING FERTILIZER

On soils of average fertility that have been manured recently, about 800 pounds of commercial fertilizer should usually be applied. When manure cannot be used in the rotation, green-manure crops should be plowed under and the amount of fertilizer may well be increased to 1,000 to 1,500 pounds or more per acre.

The rate of application and the analysis of fertilizer, the soil type, and the growing conditions naturally determine the precise method of application, but experimental results to date (1963) rather clearly show agreement among investigators on the principles involved in fertilizing tomatoes. As it is a long-season crop (3½ to 4 months) and as the nutrient requirements are heaviest during the second and third months, application methods should necessarily be adapted to supply the nutrients so they will be available during the entire crop season.

On heavy soils the fertilizer in amounts of 300 to 500 pounds per acre should be placed in a band 3 to 4 inches to each side of the row and 4 inches below the soil surface, either at the time the plants are set or at first cultivation. Although placement of 1,000 or more pounds of fertilizer per acre in a band 4 to 5 inches to each side of the row at time of planting has given favorable results in some areas on heavy soils high in organic matter, there is a possibility that injurious salt concentrations may develop if dry periods follow transplanting. It seems generally advisable, therefore, to limit the localized row application at time of setting the plants to a maximum of 500 pounds. For rates heavier than 500 pounds per acre the rest of the fertilizer should be broadcast and plowed under when the land is being prepared.

On light sandy soils where there is likely to be more leaching than on heavier soils, side dressings—particularly nitrogen and potash—are necessary to supply nutrients throughout the growing season. A part of the fertilizer should be applied broadcast and plowed under and the rest should be divided into two or three applications of 200 to 300 pounds per acre each—the first to be side-placed at the time of setting the plants and the second and third to be applied as side dressings during cultivation in furrows along the row at intervals of 3 to 5 weeks. After periods of heavy rainfall or irrigation it is commonly advisable to apply either complete fertilizer or a nitrogen-potash mixture as a side dressing to replace nutrients leached out of the root zone. A fertilizer distributor attached to the cultivator

(see fig. 9) conveys the fertilizer through a flexible tube from the hopper of the distributor to the bottom of the furrow made by the tool to which the lower end of the flexible tube is attached. The fertilizer is thus spread in an even band.

Liming

Land that is very acid in reaction (pH 5 or below) should be limed before planting tomatoes. Results obtained in experiments show that yields have been increased as much as 50 percent by liming very acid or calcium-deficient tomato land. Acidity is expressed by chemists as pH. Land having a pH value of 6.0 to 6.5 is mildly acid in reaction and is the optimum for tomatoes. Some soils have pH readings of 5.0 to 4.5 unless regularly limed. On such soils tomatoes are benefited markedly by an application of 1 to 2 tons of finely ground limestone. In soils deficient in magnesium, dolomitic limestone, which contains both calcium and magnesium lime, should be used. Some soils are naturally too alkaline for tomatoes. This is an important problem in California where whole areas or sometimes just spots in fields that are alkaline must be avoided or thoroughly leached before cropping.

Because there are wide variations in the lime requirements of soil in different areas where tomatoes are grown and because it is not practical to consider in detail all the various soil needs in a general bulletin, it is recommended that growers consult their county agents and State agricultural experiment stations whenever in doubt as to the grade or amount of fertilizer to use or the quantity of lime to apply.

FIELD PLANTING

Time of Planting

Time of setting tomato plants in the field is governed by the weather and by the best time to market to avoid too much competition and market gluts. Although these considerations apply both to processing and to fresh-market tomatoes, they are especially important in growing fresh-market tomatoes.

Tomatoes grow best with average monthly temperatures of 70° to 75° F., but can be grown in average temperatures as low as 65° and as high as 80°. Tomato growth is impaired by chilling below 50°, with definite chilling injury occurring around 40°. The least freeze will kill tomatoes. Temperatures that fall below 55° or rise above 95° for several hours when flowers are open at pollination time usually result in no fruit set or a poor set.

In the Northern States the first planting dates shown in table 1 are generally the earliest safe dates for planting early market tomatoes after danger of frost has passed. Plants for the tomato-processing crop are usually field-planted in these same States a week or two later than the earliest market crop. Production records show that the long-season main-crop tomatoes used for processing usually produce the heaviest tonnage when field-planted as soon as the soil and air have warmed sufficiently and danger of chilling is past. The latest planting dates shown for these States refer to the planting of the late-market crops.

In regions of mild winter climate, such as southern Florida and southern California, field planting is timed primarily so the tomatoes will reach the markets when there is likely to be the least competition. Athough some part of California harvests and markets tomatoes during every month of the year, the greatest period of production for market is from June to November, with most of the shipments to the East being made during October and November. The States that lead in supplying tomatoes for the New York and Chicago markets seem to have little overlap in their periods of shipment. In shipping to New York, for example, Florida supplies this market from December to May, Texas from May to August, New Jersey from July to September, California during October and November, and Texas and California during December. However, tomatoes grown in Mexico and in some of the Caribbean Islands compete more or less with these States, especially during the winter months.

Setting Plants in the Field

Tomato plants should be transferred to the field with as little shock as possible. The land should have been plowed and worked with a harrow in advance, and any needed liming and fertilizing done. The final preparation should be done just before setting the plants. This usually consists in harrowing and leveling the soil until a smooth, even, and deep plant bed is made and weeds are destroyed.

When possible transplanting should be done either during the afternoon or on a still, cloudy day. Before removing the plants from the bed the soil in which they are growing should be thoroughly watered. "Pulled" and shipped plants without soil on the roots should be protected from direct exposure to sunlight and from drying winds. A moist covering of burlap over the plants while they are waiting to be planted will help prevent excessive wilting. Tomato plants grown in plant bands or blocks of soil that can be transferred and set in the field without disturbing the roots have considerable advantage over plants "pulled" from the soil, because this operation destroys most of their root systems. Nevertheless, most of the plants that produce the large acreages of market and processing tomatoes are "pulled" and set in the field with bare roots. The cost of growing and transporting millions of plants, each rooted in its own soil, would be prohibitive.

"Pulled" plants produce highly satisfactory crops when given good care, especially the care given between pulling and planting. They also can be planted more rapidly and economically than plants with soil about the roots, either by hand or by transplanting machines. Most of the transplanting machines have a water tank and self-watering device attached that pours $\frac{1}{4}$ to $\frac{1}{2}$ pint of water or nutrient solution on the roots of each plant as it is set. Most of the small acreages are still planted and watered by hand. Hand planting is necessary when the roots are in a block or ball of soil.

If planted during dry weather, tomato plants should always be "watered in," and it is an advantage to set them deep in the soil or, if the plants are tall, at an angle so that relatively few inches of the tops will be exposed above the soil.

In some market districts where the seeds or plants are likely to be exposed to chilling temperatures or frosts when planted or when the crop is maturing, it is common practice to use some protective cover.

In California, Coachella and Imperial Valley growers use glassine caps as well as protection by brush. Tomato seed is sown in hills and the hills are covered with glassine paper caps. After the seedlings are several inches high the cap is opened on the leeward (east) side to expose the plants gradually to the cooler outside air. This process is continued until finally the cap is removed, after frost danger is past. Frequently the use of caps is combined with protection from brush and paper. Posts are set at intervals of 100 feet along the top of the bed slanted at an angle of 45°, except the end posts, which are set deeper and erect. A strand of wire is stretched between the posts. Pieces of brush (arrowweed) are pushed into the soil 6 to 8 inches apart and slanted over the plant row. Paper about 30 inches wide is placed over the brush resting on the strand of wire. More brush is added on alternate sides of the paper and a second strand of wire added to hold brush and paper in place. Caps are used mostly in the spring but brush and smudges are sometimes used to protect maturing tomatoes from frost in late fall.

Transplanting Solutions

In many tomato-growing areas a large proportion of the growers use nutrient transplanting solutions, also called starter solutions, when setting tomato plants. Usually this treatment stimulates growth. Because of this faster and more thrifty growth, the treated plants commonly start ripening fruit a few days to a week earlier than untreated plants, and the total production is usually increased. A starter solution is recommended for plant setting except where fertilizer has been placed directly in the rows.

A starter solution should have a relatively high phosphorus content and also contain some nitrogen and potash. Two parts commercial ammonium phosphate (11–48–0) and 1 part nitrate of potash produce a mixture containing about 12 percent nitrogen, 32 percent phosphoric acid, and 15 percent potash. It contains both nitrate and ammonia nitrogen and also has the advantage of supplying most of its phosphate in a soluble form that is available to the plants. Five pounds of this mixture dissolved in 100 gallons of water makes a satisfactory starter solution to be applied at about ½ pint per plant. There are variations of this formula that are available under trade names with directions for use.

Some growers prefer to use a high-analysis commercial fertilizer, even though a part of the material is left as a sludge. When highly concentrated fertilizers such as 13–26–13 are used the quantities of insoluble residue may be negligible. Certain other formulas are not so completely water-soluble. When a part of the fertilizer is insoluble, time must be allowed for the insoluble portion to settle out and only the liquid used to keep the distributor valve on the transplanter from clogging. In any case it is best for the grower to follow local recommendations with regard to the preparation and dilution of starter solutions and conditions under which they should be used.

Planting Distances

The best spacing of rows and of plants in rows depends largely on the method of culture, the variety used, and the fertility of the soil.

Tests have shown that unpruned and untrained medium-sized tomato varieties planted on moderately fertile soil will usually produce the heaviest yield per acre when set 3 by 5 or 4 by 4 feet apart. These spacings require 15 and 16 square feet per plant and 2,902 and 2,722 plants, respectively, per acre. On soils of high fertility main-crop sorts often produce best when planted 3 by 6 or 4 by 5 feet apart. These spacings require only 2,420 and 2,178 plants, respectively, per acre.

Wider distances of 5 to 6 feet between rows with closer spacings of 2 to 3 feet of plants in the rows have become more popular with increased use of power machinery in tomato fields, because these wider rows make cultivating, spraying, and harvesting easier with less damage to the plants. California growers thin their field-seeded tomatoes to stand 1 to 2 feet apart in rows spaced 5 to 6 feet.

The small-vined early-market tomato varieties, especially the determinate, or "self-topping," ones, are usually planted in 3½-foot rows with the plants spaced to 2 to 2½ feet apart. About 6,250 plants are set per acre with this spacing.

Tomatoes under intensive culture where the plants are staked and pruned to a single stem, as in the Merced district of California, are set 15 inches apart in rows 3 feet apart, using about 11,350 plants to the acre. In some New England States, the plants are set in double rows 18 inches apart with a 3½-foot space between double rows. This method requires nearly 12,000 plants per acre.

TRAINING AND PRUNING

In the commonest method of training and pruning tomatoes, in the greenhouse and certain market-crop districts, the buds that would develop into lateral branches are removed. These buds appear at the point where the leaf stem joins the main stem. The fruit-bud clusters appear on the opposite side of the stem, usually above or below the points on the stem where the leaves are attached. The lateral shoots should be removed while small to conserve the energy of the plants for the foliage and the fruit of the central stems and to avoid making large wounds on the plants. They should always be pulled or broken out of the leaf axils, as pinching or cutting them off is more likely to spread virus diseases. The growth of the plants is thus limited to the central stem, which is kept erect by tying it to some support.

Early-market growers, particularly in northern sections, employ various methods of supporting the plants. Some use stout 6- to 8-foot wooden stakes driven in the ground 3 inches from the base of each plant. Other growers use light bamboo or heavy-gage wire stakes tied at the tops to a horizontal wire supported on posts or use regular trellis posts and wire. Sometimes two or three stems are allowed to develop and these are each trained to separate supports.

In some localities the central terminal bud of each plant is removed after five or more good fruit clusters have started to develop, in order to prevent the formation of later fruit clusters and to conserve all the food manufactured by the plant for the growth of the fruit already set. In general this is no advantage, because it limits leaf area too much.

The advantages and disadvantages of training and pruning tomato plants as compared with allowing the plants to grow naturally have been tested in various localities. These experiments indicate that training and pruning, because of closer planting, results in heavier total acre yields, but the method reduces the production of each plant. Fruits that are kept off the ground are less subject to fruit decays and are easier to pick. However, training and pruning tomato plants involves much higher cost of production per acre for labor, plants, and materials and, therefore, this method is commonly unsuitable for crops that must be sold at relatively low prices, as those for processing. In addition, when the plants are trained the fruits are more subject to sunscald and to blossom-end rot.

CULTIVATION

The principal purpose of cultivating tomatoes is to eradicate weeds. Frequent shallow cultivations, 1 to 2 inches deep, should be given tomatoes, especially during the first month after field planting. Cultivation at this time will reduce the labor necessary to control weeds after the plants begin to spread. A modern tractor cultivator can fertilize and cultivate a field of tomatoes in one operation (fig. 9).

The first cultivation may be fairly close to the recently set plants, but later cultivations should be shallower and farther from the stems. A healthy tomato plant has an enormous spread of feeder roots close to the surface as well as at considerable depth in the soil. When these surface roots are partially destroyed by cultivating too deep or

Figure 9.—**A modern tractor cultivator equipped with a fertilizer distributor for side dressing tomatoes.**

too close to the plant, fruit production will usually be decreased significantly. Cultivation should not be continued when the plants have spread out in the rows so that the vines and growing fruit as well as the roots will be injured by the cultivating equipment.

Hand hoeing may be necessary to eliminate weeds between the plants in rows cultivated in one direction only. If rows are planted in checks, cultivation in two directions will greatly reduce hand work. Weeds not only rob the soil of moisture and plant food, but some weeds are also carriers of tomato diseases.

Whenever tomato vines are wet with dew or rain, allow them to dry before cultivating, hoeing, or handling them in any way. Such operations tend to spread the spores of various tomato diseases. Brushing against the vines while walking through the field when they are wet is likely to increase the spread of diseases.

IRRIGATION

A good supply of moisture stored in a deep soil before the planting season will help to supply the water requirements for a good tomato crop. Irrigation of tomatoes is not usual in the Southern and Eastern States, because the moisture requirements of tomatoes are usually met in normal seasons. If irrigation becomes necessary, it is best to allow the water to soak into the soil without wetting the foliage and fruit.

The most important production of tomatoes under irrigation is in the interior valleys of California. Adequate irrigation wets all the soil in the root area. Enough water should be used to keep the plants growing steadily without wilting. Insufficient moisture may be detected by a slowing or stoppage of growth and a dark grayish-green appearance of the foliage. Adequate irrigation in large field operations is provided by a system of open ditches from which water is brought to the plants by shallow furrows between the rows. If a field does not have ample soil moisture at planting time a light irrigation should be made as soon as the plants are set. A small furrow close to the plants on either side is satisfactory for wetting the soil close to the roots. The number and frequency of subsequent irrigations are determined by type of soil, climate, and competing farm operations. Sandy soils need more frequent irrigation than do clay and other heavy soils. Moreover, hot regions, where the rate of evaporation is high, as in the Imperial Valley of California, need more water than do cooler regions.

Tomatoes are a deep-rooted crop when grown in deep porous soils that are free from impervious (hardpan) layers. The roots of most main-crop sorts commonly extend to a depth of 6 or more feet, and in exceptionally deep soil have been known to grow to a depth of 10 to 12 feet. When the roots extend through such a large volume of soil which is filled with available water, considerable growth is sustained without any irrigation in the cooler areas.

A soil auger can be used to examine soils at definite depths for moisture content. The wetness of soil may be roughly estimated by its appearance and feel. Tests made in the central valleys of California indicate that tomato plants growing there use the following amounts of water: June, 3.2 inches; July, 4.5 inches; August, 7 inches; September, 5.2 inches; and October, 4.1 inches—a total of 24 inches.

In the coastal areas where the soil at planting time is full of moisture from winter rains the California Agricultural Experiment Station recommends 10 to 12 inches of irrigation water for completing the crop.

Whenever it becomes necessary to irrigate tomatoes, the soil should be thoroughly soaked so that the entire root zone is wetted. It is best to have the soil well supplied with water just before the harvest begins, so that the need for subsequent irrigations will be reduced to the minimum to avoid so far as possible cracking of the ripening fruits. Cracking increases the likelihood of fruit decays.

DISEASES

Tomatoes are subject to a number of diseases. These are caused by fungi, bacteria, viruses, and certain unfavorable soil or climatic conditions. The prevention of serious losses from disease is an essential part of profitable tomato production. Some of the more important diseases of field-grown tomatoes are damping-off, fusarium wilt, early blight, late blight, septoria leaf spot, and anthracnose. All these diseases and others that commonly affect tomatoes are fully described and methods of control are discussed in Agriculture Handbook No. 203, "Tomato Diseases and Their Control," available at 40 cents per copy from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

INSECT PESTS AND THEIR CONTROL [3]

Many insects attack the tomato plant. Some of them are important pests of the tomato every year in some parts of the country and periodically elsewhere. The most common and widespread of these pests are cutworms, the potato and tobacco flea beetles, the tomato fruitworm, and the tomato and tobacco hornworms. The tomato pinworm is destructive in California and has been recorded as damaging field-grown tomatoes in Florida. The tomato psyllid and the beet leafhopper are prevalent in several States in the West and in some years cause considerable loss to tomato plantings. The tomato russet mite causes serious injury to tomatoes in California if not controlled, and may cause damage in other States. Aphids and spider mites occasionally damage tomatoes in the field, and drosophila flies are pests in the picking boxes between harvest and delivery to the canneries and in the field.

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[3] The scientific names of the insects discussed in this section follow:

Common name	*Scientific name*
Drosophila flies	*Drosophila* sp.
Green peach aphid	*Myzus persicae* (Sulz.).
Potato flea beetle	*Epitrix cucumeris* (Harr.).
Tobacco flea beetle	*Epitrix hirtipennis* (Melsh.).
Tobacco hornworm	*Protoparce sexta* (Johan.).
Tomato fruitworm	*Heliothis zea* (Hbn.).
Tomato hornworm	*Protoparce quinquemaculata* (Haw.).
Tomato pinworm	*Keiferia lycopersicella* (Busck).
Tomato, or potato, psyllid	*Paratrioza cockerelli* (Sulc).
Beet leafhopper	*Circulifer tenellus* (Baker).
Tomato russet mite	*Vasates lycopersici* (Massee).
Tomato leaf miner	*Lyriomyza munda* (Frick).
Two-spotted spider mite	*Tetranychus telarius* (L.).

Aphids

Aphids or plant lice frequently occur on tomato plants. They damage the plants by transmitting mosaic disease. They may become so numerous that they devitalize the plants, and exude honeydew to the extent that both the fruit and plants are covered with a sooty fungus. The most common aphid on tomatoes is the green peach aphid. In the wingless form this is usually light green in color, varying from 1/5 to 1/2 inch long. It is usually found on the undersides of the leaves.

Usually it is not necessary to make separate applications for aphid control, and frequently the aphicides can be combined with insecticides being used for tomato fruitworm control. Diazinon at 3/4 pound per acre, malathion at 1 1/4 pounds, and Phosdrin at 1/2 pound may be used in dust or sprays, and endosulfan at 1 pound may be used in a dust. Applications should be directed to the undersides of the leaves where most of the aphids will be found.

Cutworms

Cutworms may cut off young tomato plants at the soil surface wherever this crop is grown. There are many kinds of cutworms. The commoner ones are stout, soft-bodied, smooth, or nearly smooth, cylindrical in shape, varying from gray to brown or nearly black and sometimes spotted or marked with stripes. They vary from 3/4 to 1 1/2 inches in length. They can be controlled by applying toxaphene or DDT in a dust or spray at 2 pounds per acre to the plants and to the soil around the base of them. A bait containing 3 percent of toxaphene in bran is very effective when moistened with enough water to make a crumbly mash. Apply the bait at 40 pounds per acre to the soil around the young plants, preferably in the evening. Commercial apple baits are also effective.

Tomato Leaf Miner

The adult leaf miner is a yellowish and black two-winged fly about 1/8-inch long. The larvae are small white maggots which live and feed between the surfaces of the leaves, resulting in light-colored serpentinelike mines. These mines can become so numerous that the plants are devitalized and so many leaves die that the fruit is exposed to sunburn.

This insect can be controlled by applying parathion at 1/2 pound per acre or diazinon at 3/4 pound in a dust or spray at 2-week intervals beginning at the time of fruit setting. These insecticides can frequently be combined with the insecticides used for tomato fruitworm control so that separate applications are not necessary.

Flea Beetles

The potato flea beetle and the tobacco flea beetle are black or dark-brown insects about twice as large as a pinhead. These flea beetles eat small holes in the tomato leaves. They are particularly destructive to the young tomato plants in the seedbed and also in the field soon

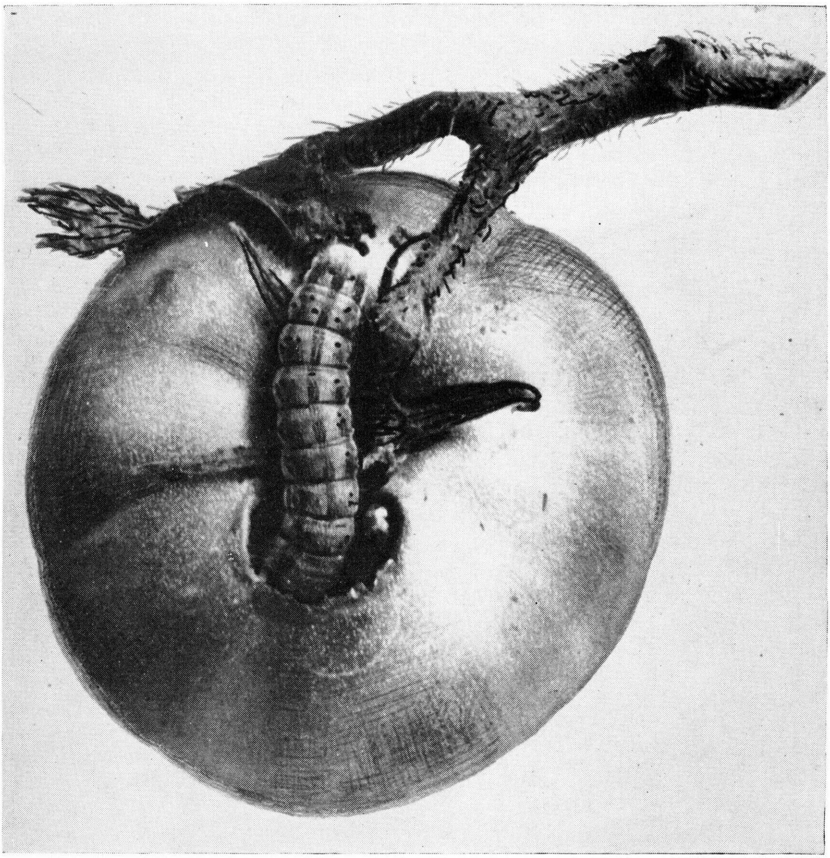

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Figure 10.—**Tomato fruitworm burrowing into a tomato.**

after they are set out and before they become well established. They are attracted more to the wilted transplants than to those that are in a thrifty growing condition.

Flea beetles can be controlled by applying DDT or methoxychlor at 1½ pounds per acre in dusts or sprays, or toxaphene at 3 pounds in a dust. Apply as soon as damage is noticed and repeat at 5-day intervals until infestation is controlled.

In the plant bed use ½ pound of the dust to 100 square yards. In the field on small plants use 8 to 10 pounds per acre, applying the dust directly to the plants.

Tomato Fruitworm

The tomato fruitworm (fig. 10), also known as the corn earworm and the bollworm, is a green or brown caterpillar with light stripes, about 1½ inches long when mature, which burrows into the fruits and renders them unfit for food.

The most effective insecticides are DDT and TDE at 3 pounds per acre, Sevin at 2 pounds, and toxaphene at 5 pounds applied in a dust

or spray. Apply one of these materials three times at 2-week intervals, beginning when the first fruits of the main crop are setting. Cover the plants thoroughly, especially the growing tips and outer leaves, where the insect's eggs are laid. One of these insecticides can be combined with parathion or diazinon for joint control of fruitworm and leaf miner, or with sulfur or parathion for joint control of fruitworm and russet mite. DDT at 1 pound per acre is frequently combined with toxaphene at 3 pounds for joint control of fruitworm and russet mite.

For further information, see USDA Leaflet No. 367, "The Tomato Fruitworm, How to Control It."

Hornworms

The hornworms are large green or brown caterpillars about 4 inches long when fully grown and easily recognized by the hornlike structure on the end of the body. Two kinds of hornworms, known as the tomato hornworm and tobacco hornworm, respectively, occur commonly on tomato. The tomato hornworm has a prominent V-shaped white or light-yellow mark on the side of each segment of its body. The tobacco hornworm has a diagonal, white or light-yellow stripe in a corresponding position. Hornworms blend so well with the tomato plants that they are not readily detected even after they have destroyed considerable foliage. The chief damage is from their feeding on the foliage, but they sometimes feed on the fruit also.

Handpicking of the hornworms is effective in small plantings when the infestation is light, and is best done early in the morning. In large plantings use TDE or Sevin at 3 pounds per acre in a dust or spray, or toxaphene at 3 pounds in a dust. Make the first application when the hornworms become numerous and repeat when necessary.

Tomato Pinworm

The tomato pinworm is a small caterpillar about $\frac{1}{4}$-inch long, with a slender yellow or ash-gray body bearing dark-purple spots and with a light-brown or yellow head. It feeds on the foliage of tomatoes and burrows into the fruit around and under the stem, causing small pinholes. It often burrows so deeply that not all the injured portion is removed with the core in the preparation of the fruit for canning or processing.

Destruction of all discarded fruits and tomato vines immediately after harvest, followed by plowing or disking, will do much to control this pest. New tomato plantings should not be made near the fields containing eggplant and nightshade plants, which are also hosts of this insect, or near places where old plants have been piled.

DDT or TDE at 2 to $2\frac{1}{2}$ pounds per acre, applied in a dust or spray, has been most effective when applied in 4 applications at 10- to 14-day intervals. The first application is made when the fruit is about 1 inch in diameter and the last is made soon after the first picking.

Tomato Psyllid

The tomato psyllid (also known as the potato psyllid) is a small jumping plant louse, about $\frac{1}{10}$ inch long and light green to gray with

prominent white bands across the body. Feeding by the nymphs causes a disease in the tomato plants, which is known as psyllid yellows. The older leaves thicken and at the basal portions curl upward, often with the leafstalk twisting. The younger leaves show slight purpling along the veins and outer margins, and the rest of the leaf usually becomes a light or yellowish green. The growth of the plant is stunted, and the plant tops acquire a leathery appearance. If the plant is attacked when small, the spaces between the joints are shortened and the plant may fail to fruit or will set only a few fruits, which remain small. On larger plants, when the attack is severe the space between the joints may be lengthened and the leaves narrowed, and many fruits set near the ends of the branches, but the fruits remain small and are inferior in quality. They have a yellowish cast on the exterior, and the interior central mass and partition walls have abnormal color upon ripening, may be rough and even rubbery, and have an insipid taste.

DDT is the most effective material for the control of the tomato psyllid at 1 to 1¾ pounds per acre in a dust, or 1 pound in a spray. Make the first application when the plants are about 6 inches high if the psyllid is present in the area and repeat at 10-day intervals until at least three applications have been made. As the nymphs of the psyllid feed on the undersides of the leaves, be sure to cover these parts thoroughly with the insecticide.

Beet Leafhopper

In southern California and the intermountain areas of the West the beet leafhopper is frequently a serious menace to the tomato crop. This insect, commonly known in the West as the whitefly, is slightly more than ⅛ inch long and gray to greenish yellow in color. Moving from its desert breeding areas into the fields soon after transplanting time, it feeds upon the young tomato plants and transmits to them a virus that causes a disease known as curly top, or tomato yellows. The disease is recognized by an inward rolling of the leaflets along the midrib, giving them a drooping appearance. The leaves may also become thickened and crisp, and the stems hollow through the drying of the pith. The growth of the plant is arrested, and the plant assumes an erect or rigid habit. If small fruits have formed, they ripen prematurely. The roots of the diseased plants decay, the leaves and stems turn brown, and finally the plant dies.

Experiments in Utah have indicated that losses from curly top may be reduced by setting two tomato plants about 6 inches apart in each hill. Covering the plants with cheesecloth for the first month after they are transplanted to the field will also protect them from infection. One square yard of cheesecloth is supported by two pieces of wire 42 inches long, crossing at right angles so that the cloth forms a large "hot cap" over the plant. The cloth is held in place over the wire by covering the lower edge with soil (fig. 11).

Tomato Russet Mite

The tomato russet mite is so tiny that it cannot be seen with the naked eye. Infested tomato plants have a russeted appearance, and in severe infestations the leaves become dry and have a paperlike

Figure 11.—**Cheesecloth cover to protect young tomato plants from curly top disease.**

consistency. This condition exposes the fruits to damage by sunburn or sunscald.

Control of this pest has been accomplished satisfactorily in most cases by incorporating 20 to 50 percent sulfur in the dusts used for tomato fruitworm control. Wettable sulfur can also be used at 10 pounds per acre in a spray. Parathion at ½ pound per acre and toxaphene at 5 pounds are effective in cool as well as warm weather and should be preferred to sulfur in cool weather. They can also be combined with other materials, either in dusts or sprays for tomato fruitworm or tomato pinworm control. In areas where this pest occurs regularly, applications should be started at fruit setting and continued at 2-week intervals.

Drosophila

Drosophila flies, or vinegar gnats, are yellowish, clear-winged flies about $\frac{1}{10}$ inch long with reddish eyes and black stripes across the body. There are a number of related species. They lay masses of tiny white eggs on the exposed flesh of tomatoes wherever the skin is broken by growth cracks or rough handling. These eggs hatch in about 24 hours into tiny transparent-to-cream colored maggots. These eggs and maggots contaminate the tomato product and render it undesirable for food.

To control drosophila, a community-wide program of sanitation must be followed, not only in and around the canning plant but in the field. Care must be taken to minimize the crushing of fruit in harvesting procedures and to prevent the accumulation of overripe spoiled tomatoes or other fruit or fruit wastes anywhere in the area. The use of insecticides is helpful but is not a substitute for sanitation

at the farm and the cannery, and care in handling the fruit. It is helpful to treat the field with malathion at 2 pounds per acre, aldrin at ½ pound, or diazinon at ¾ pound. To protect the tomatoes in transport, dust the tomatoes in the field boxes or baskets immediately after harvest with a mixture containing 0.1 percent of pyrethrins, or 0.075 percent pyrethrins plus 0.75 percent of piperonyl butoxide. Avoid storing unprocessed tomatoes overnight.

Spider Mites

Several species of spider mites occur on tomatoes but the most common is the two-spotted spider mite. These mites vary in color from yellow to green or red, and are so small that they are barely visible to the naked eye. They devitalize the plants by sucking the juices out of the leaves and stems. Some species spin webs on the plants.

Kelthane at 1 pound per acre as a dust and ½ pound as a spray, and malathion at 1¼ pounds, parathion at ½ pound, and carbophenothion at 1 pound can be used in dusts or sprays for control of spider mites. Control applications should be directed mainly to the undersides of the leaves where the mites are usually most numerous.

Application of Insecticides

Insecticides can be applied to plants as dust, as high-gallonage sprays using wettable powders in 100 to 150 gallons of water per acre, or as emulsion sprays using 10 to 20 gallons of water per acre. The 3 methods are equally effective and can be used with either hand or power equipment. Make sure that all the foliage on the plants is covered by the insecticide. With hand equipment it is advisable to treat the plants from each side of the row. With power machinery it is advisable to have at least 2 nozzles per row. Applications should be made when there is little or no wind.

Precautions

Insecticides are poisonous. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the container label. Insecticides should be kept in closed, well-labeled containers, in a dry place where they will not contaminate food or feed, and where children and pets cannot reach them.

In handling any insecticide, avoid repeated or prolonged contact with skin and inhalation of dusts and mists. Wear clean, dry clothing, and wash hands and face before eating or smoking.

DDT, Kelthane, malathion, pyrethrins, Sevin, sulfur, and TDE can be used safely without special protective clothing or devices, provided they are in diluted dusts or water sprays. However, most concentrates and oil solutions require special precautions. When handling or mixing concentrates, avoid spilling them on the skin and keep them out of the eyes, nose, and mouth. If any is spilled on the skin, bathe and change clothing immediately. If it gets in the eyes, flush with plenty of water for 15 minutes and get medical attention.

Aldrin, diazinon, endosulfan, and toxaphene can be absorbed directly through the skin in harmful quantities. When working with these insecticides in any form, take the same precautions as with concentrates.

Parathion and Phosdrin are extremely poisonous and may be fatal if swallowed, inhaled, or absorbed through the skin. Carbophenothion is highly toxic if inhaled or swallowed. These insecticides should be applied only by a person thoroughly familiar with their hazards and who will assume full responsibility for safe use and comply with all the precautions on the labels.

If you must transplant or otherwise handle plants within 5 days after treatment with parathion, or within 1 day after treatment with Phosdrin, protect your skin by wearing clean, dry cotton gloves. If you must work in close contact with treated crops, as in thinning or harvesting, you also should wear tightly woven clothing.

Do not apply parathion within 10 days before a harvest, carbophenothion within 7 days, DDT within 5 days, toxaphene within 3 days, Kelthane within 2 days, or Phosdrin, TDE, malathion, diazinon, endosulfan, pyrethrins, aldrin, or Sevin within 1 day before a harvest.

To protect fish and wildlife, be careful not to contaminate streams, lakes, or ponds with insecticides. Do not clean spraying equipment or dump excess spray material near such water. Avoid contaminating pasture grass or feed.

Additional Information on Insects

Additional information on the control of insects on tomatoes in your area may be obtained from your State Agricultural Experiment Station or county agent.

HARVESTING AND HANDLING [4]

At what stage of maturity tomatoes should be harvested depends on the purpose for which they are to be used. Tomatoes grown for processing, such as for canning, juice, and paste, are harvested full-ripe to insure the desired quality and red color in the product. Tomatoes that are to be distributed locally can be harvested nearly full-ripe; they can be harvested for relatively nearby markets when they begin turning to pink. Quality characteristics such as flavor, texture, and color in vine-ripened tomatoes are superior to those harvested at earlier stages of maturity, but it is not practical to ship pink or ripe fruits to distant markets. Tomatoes to be shipped to distant markets are harvested at a mature-green stage and ripened after reaching the market. Three distinct stages, therefore, are recognized commercially in the marketing of tomatoes—ripe, pink, and mature-green.

[4] Additional information on handling, transportation, and ripening can be obtained by writing the Agricultural Marketing Service, United States Department of Agriculture, Plant Industry Station, Beltsville, Md.

Picking Tomatoes for Processing

The processing industry desires tomatoes that are highly colored, with the red color evenly distributed through the flesh of the fruits. The first step in producing tomatoes of high quality is to grow varieties that are adapted to the region and those especially desirable for processing. When tomatoes are left on the vines until fully ripened, the product not only has the maximum of color but also has the high quality of texture and flavor found only in vine-ripened fruits. The relatively short time between harvesting and processing makes it possible to utilize tomatoes of this late stage of ripeness. Conditions most favorable for ripening tomatoes on the vines are moderately warm weather, bright sunshine, and vigorous plants with sufficient leaf coverage to keep the fruits shaded and relatively cool.

Rate of ripening and color development are affected by the temperature of the fruit. The air temperatures over the field may be very hot for a short time without adversely affecting the ripening process, provided the temperature within the fruits does not become higher than 80° F. The ripening of tomatoes is accelerated as the internal temperature of the fruits rises, but development of red color (lycopene) in the fruits is slowed down and practically ceases as fruit temperature approaches 86°. On the other hand, yellow color (carotene) continues to develop at higher temperatures. This is the reason tomatoes ripening in prevailing temperatures above 85° are yellowish red or pale red. Healthy green foliage not only shades the fruit and prevents heat injury, such as sunburn and sunscald, but also tends to cool them by absorbing heat and by giving off moisture from the leaf surfaces.

To obtain the highest quality pack harvesting crews should be trained to recognize the most desirable stage for picking tomatoes for canning. Only full-colored ripe fruits should be picked; all fruits that have not yet reached the proper color stage should be left on the vines for later picking. Tomatoes continue to increase in size until fully ripened and therefore produce a heavier total yield as well as a higher grade canned product than fruits not fully ripe.

The intervals between pickings depend somewhat on the weather. In most tomato-growing regions of the country, tomatoes should usually be picked at 4-day intervals during warm weather and at weekly intervals only when the weather is cool. However, the weather and soil conditions of California usually enable growers to pick at 7-day intervals. If left on the vines too long the fruits become soft-ripe. In this stage they are more likely to crack open on the vine or to become ruptured during handling. Cracking or wounding is usually followed quickly by fermentation and the invasion of various fungi, which increase the mold count and produce a low-grade processed product. Much care should be taken to avoid bruising the fruit or breaking the skin during harvest. Tomatoes should not be pulled from the vines but picked with a twisting motion of the hand so that the fruit will separate from the stem. A stem that remains attached to the fruit must be removed before laying the fruit in the picking basket. Hampers and field boxes should be filled only level with the top, as overfilling will cause crushing of many fruits.

Tomatoes should be delivered to the processing plant as soon as

possible after picking, and they should be protected from exposure to the sun during the interval between picking and processing. When possible tomatoes should be picked only when the vines are dry; the fruits are more subject to spoilage, and foliage diseases are more likely to be spread by the hands and clothing of pickers during rainy weather.

Picking Tomatoes for Market

FOR NEARBY MARKETS

Tomatoes that are to be sold on local markets during cool weather should be in either the pink or firm-ripe stage of maturity when harvested. When the weather is warm or the time involved between harvest and consumer is more than 2 or 3 days, tomatoes should be picked at the turning, or "breaker," stage of maturity. Tomatoes showing a small spot of color at the blossom end are considered to be in the turning, or "breaker," stage; when most of the fruit surface is pink or red, the term "pink" stage is used; when the fruits are colored but have not reached a stage of optimum ripeness, they are termed "firm ripe." Tomatoes for nearby markets should be picked as often as necessary to prevent them from becoming overripe. During the height of the season it is often necessary to pick every second day. Weather conditions have an important influence on the frequency of picking.

In many localities there is real need for improvement in the handling and marketing of tomatoes in the advanced stages of maturity. Every precaution should be taken to prevent mechanical injury. Such precautions should start with the harvesting of the crop. Picking containers should have smooth inner surfaces and should be small enough to prevent bruising caused by the weight of the fruit. If the tomatoes are transferred to field boxes for hauling to the packing shed, the boxes should be filled only about two-thirds full to prevent bruising and crushing; the fruits should be transferred by hand, not poured. Also better containers than the $5/8$-bushel hamper and the bushel basket so often used are needed for marketing pink tomatoes. Great losses are incurred, both directly through spoilage and indirectly through off-flavor, because of the serious bruising of ripening tomatoes marketed in containers that hold too much fruit. Marketing graded tomatoes in baskets of 8 to 10 pounds' capacity, such as the climax, splint, and fiberboard baskets used in marketing greenhouse-grown tomatoes, would reduce losses, increase quality, and bring greater returns to the grower.

FOR DISTANT MARKETS

Tomatoes shipped to distant markets are harvested at the mature-green stage. At this stage the fruits are about full-grown, but they show no pink color. They are usually referred to in the trade as "green-wrap" tomatoes.

The size of the fruits should not be used as a guide in tomato picking, because maturity is determined by stage of development and not by size. When tomato fruits have reached the mature-green stage, cream-colored streaks are noticeable at the blossom end; the brown

Figure 12.—**Packages widely used in shipping fresh tomatoes: (Left to right) 60-pound bulk field box with padded top; 30-pound packed lug; and 60-pound wire-bound box with ventilated liner.**

corky ring surrounding the stem scar becomes more prominent; the skin is tougher so that it is not easily broken or rubbed loose in scraping it with the thumbnail; and the fruit yields more readily to slight hand pressure. Growers can test their judgment of maturity by cutting fruits crosswise of the seed cells. If the pulp that surrounds the seeds has become jellylike and the seeds slip aside and cannot be cut by a sharp knife in slicing, the tomatoes are considered mature enough to ship. Tomatoes that have not developed the jellylike condition have soft, white seeds that are easily cut in slicing the fruits. These are definite signs of immaturity, and such fruits should not be harvested. Immature tomatoes—if they ripen—ripen much slower than mature-green ones and usually shrivel in the ripening room, resulting in poorly colored fruits tough in texture and inferior in quality. Increased tonnage can be obtained by allowing the fruits to remain on the vines as long as possible, taking care that they are harvested before too ripe. During the 4-day period just before tomatoes start to turn there is approximately a 12-percent increase in size. Picking green tomatoes at the proper stage of maturity can be done by training the pickers and then by giving continuous supervision throughout the harvest. Intervals between pickings depend on weather. During cool weather the tomatoes are usually picked once a week, but during warm weather it is necessary to pick more often.

Mature-green tomatoes should be handled carefully in the picking, packing, and other handling operations to prevent skin breaks or mechanical injuries in general. Perhaps the most desirable picking container is the wire-stave egg basket or modifications of it, because it retains a minimum of sand and trash. This container is

coming into common use in certain sections. Burlap-lined hampers for picking are used by some growers. Unlined hampers, especially the 7/8-bushel size, cause injury to the fruits because of the wire staples protruding through the inner surface, and these are not recommended.

Field boxes used for hauling tomatoes to the packinghouse should be constructed with the smooth or planed side of the lumber on the inside. Boxes with rough surfaces cause skin breaks and are the principal cause of shoulder scarring in tomatoes. Shoulder scars and other skin breaks turn dark, and many become infected with rot-producing organisms. A certain amount of culling is usually done in the field when the tomatoes are transferred from the picking container to field boxes. The filled field boxes are hauled to the packinghouse, where the fruits are usually washed, waxed, sized, and graded. The size has been standardized to conform with the arrangement of the pack. Thus, if the top layer of the lug has five fruits per row crosswise and six fruits per row lengthwise, it is designated as a five- by six-pack.

The advent of prepackaging tomatoes for retail distribution has brought considerable changes in the handling of mature-green fruits. Most shipments go direct to repackers for ripening and distribution. Fruits shipped by rail and those consigned to commission merchants and jobbers are wrapped and packed in lug boxes of approximately 30 pounds' capacity (fig. 12, center). A considerable quantity of tomatoes shipped to repackers from the South Atlantic and South Central States is hauled by truck. In addition to lug boxes a great many tomatoes are shipped in bulk containers by truck. These bulk containers are the open-top field box with a pad over the top of the fruit (fig. 12, left), wire-bound boxes (fig. 12, right), and nailed, lidded boxes with liners. The majority of these containers have a capacity of approximately 60 pounds.

The extent of ripening of tomatoes in transit depends on the temperature of the fruit and the length of time en route. Most rapid ripening occurs at 70° to 75° F., and decay is much more likely to develop at these temperatures than at lower ones. The most desirable temperature range during transit is 50° to 65°.

Tomato fruits are injured by holding at low, yet not freezing, temperatures for too long a time. Ordinarily the field heat in the tomatoes when loaded is sufficient to require several days to cool the load to desirable temperatures, even by refrigeration. Fruits in the bottom bunker position, however, cool rapidly and may arrive on the market with a pulp temperature of 36° to 40° F. if the car was moved under bunker icing. Under normal conditions, if the transit period does not exceed 6 days, the tomatoes would be at such temperatures for only 2 to 4 days, and these conditions alone are not sufficient to cause chilling injury. If, however, the transit period exceeds 10 days and the load moves under refrigeration, there is danger of chilling injury in tomatoes in the bottom bunker positions. Cars moving under bunker icing for transit periods prolonged because of diversion from one prospective market to another are likely to become chilled. Chilling injury is particularly likely to occur in cars moving during periods of low outdoor temperatures and it is obvious that under these temperatures heavy icing would be undesirable. Tomatoes moving to northern markets during the winter months may need to be provided

with heater service to protect against chilling injury as well as freezing injury.

When tomatoes reach the market they should be unloaded promptly and sorted to remove those fruits ripe enough for distribution and the decayed fruits. Tomatoes to be ripened are sorted as to degree of color and placed in shallow boxes. Although tomatoes will ripen at a range of temperatures from 55° to 75° F., the best quality is obtained by ripening the fruits promptly at 60° to 70°. Tomatoes ripened at 60° are firmer and have less decay than those ripened at 70°, but they ripen somewhat more slowly. Better quality results when the air in the ripening room is moist enough to prevent shriveling. About 88 to 90 percent relative humidity is satisfactory. The humidity should not be maintained by sprinkling the tomatoes, because increased decay is likely to result.

U.S. Standards for Tomatoes

When tomatoes are sold by grade the grower who has carefully produced and handled his product is rewarded by having his tomatoes designated as high-quality tomatoes. The Federal grades for tomatoes established by the United States Department of Agriculture serve as a basis for the sale and purchase of both processing and fresh-market tomatoes. A large part of the tomatoes sold for these purposes are now purchased on the basis of such standards. The grading is done by Federal-State inspectors. Copies of these tomato grade specifications may be obtained from the Agricultural Marketing Service, United States Department of Agriculture, Washington 25, D.C. Careful harvesting at the right stage of maturity, avoiding bruising or breaking by rough handling, and proper grading will help insure better prices for the crop. Tomatoes that are below the requirements for the No. 2 grades are called culls.

GRADES FOR FRESH TOMATOES

U.S. No. 1 consists of tomatoes of similar varietal characteristics which are mature but not overripe or soft, which are clean, well developed, fairly well formed, fairly smooth, and which are free from decay, freezing injury, and sunscald and free from damage caused by bruises, cuts, and broken skins, internal discoloration, sunburn, puffiness, catfaces, other scars, growth cracks, hail, insects, disease, or mechanical or other means.

U.S. Combination consists of a combination of U.S. No. 1 and U.S. No. 2 tomatoes: Provided, that at least 60 percent, by count, meet the requirements of U.S. No. 1 grade.

U.S. No. 2 consists of tomatoes of similar varietal characteristics which are mature but not overripe or soft, which are clean, well developed, reasonably well formed, which may be slightly rough, and which are free from decay, freezing injury, and sunscald, and free from serious damage caused by bruises, cuts and broken skins, internal discoloration, sunburn, puffiness, catfaces, other scars, growth cracks, hail, insects, disease, or mechanical or other means.

U.S. No. 3 consists of tomatoes of similar varietal characteristics which are mature but not overripe or soft, which are clean, well de-

veloped, which may be misshapen, which are free from decay and freezing injury, and free from serious damage caused by sunscald, and from very serious damage caused by bruises, cuts and broken skins, internal discoloration, sunburn, puffiness, catfaces, other scars, growth cracks, hail, insects, disease, or mechanical or other means.

GRADES FOR CANNING TOMATOES

U.S. No. 1 consists of tomatoes that are firm, ripe, well colored, well formed; free from molds and decay and from damage caused by growth cracks, worm holes, catfaces, sunscald, freezing injury, or mechanical or other means.

U.S. No. 2 consists of tomatoes that do not meet the requirements of the foregoing grade but which are ripe and fairly well colored and which are free from serious damage from any cause. Minimum size may be fixed by agreement between buyer and seller; tomatoes below this specified minimum size are classed as culls.

GRADES FOR PROCESSED PRODUCTS

U.S. No. 1 consists of tomatoes that are fairly firm, ripe, well colored, and free from stems and from damage caused by badly discolored cracks, shriveling, molds, decay, sunburn, sunscald, freezing, or other means.

U.S. No. 2 consists of tomatoes that do not meet the requirements of the foregoing grade but which are ripe and fairly well colored and which are free from serious damage from any cause.

California, which produces about half the processing crop of the whole country, was still using its local tomato-grading system in 1960.

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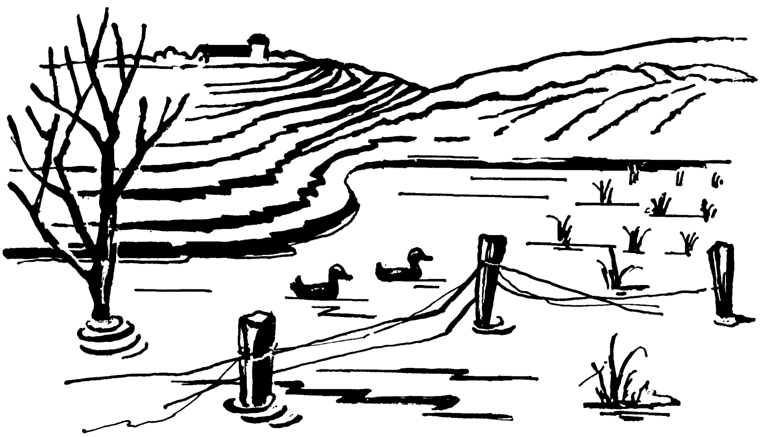

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